

A Review on the Use of Live Baitfishes to Capture Skipjack Tuna, *Katsuwonus pelamis*, in the Tropical Pacific Ocean With Emphasis on Their Behavior, Survival, and Availability¹

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ABSTRACT

The use of live baitfishes in the Pacific Ocean skipjack tuna fishery is reviewed primarily to provide essential information for future baitfish investigations and as a useful reference for fishery development. Emphasis is placed upon various baitfish characteristics such as size, coloration, body form, behavior, schooling, survival in captivity, and their suitability for capturing skipjack tuna, *Katsuwonus pelamis*, by pole-and-line methods. In addition, data on their capture and handling methods are given. Thirty-one baitfish families are included in the text and pertinent information on each family is summarized in two tables. A total of approximately 160 baitfish species are discussed in the text and their area of geographical use recorded in a table and map of the Pacific Ocean. Recommendations for future research related to the use of baitfishes and an extensive bibliography are included.

INTRODUCTION

The dependence of the commercial pole-and-line fishery for skipjack tuna, *Katsuwonus pelamis*, on live baitfishes throughout the warm Pacific Ocean is a leading factor controlling the expansion of this fishery (Rothschild and Uchida 1968). Skipjack tuna represent an extensive fishery resource in the oceanic regions of the Pacific currently underharvested due primarily to insufficient supplies of live baitfishes. Extensive investigations have been done on the distribution and biology of skipjack tuna but less is known of the baitfishes on which this fishery depends. Literature on the development of this fishery in the central and western Pacific has been reviewed by Hester and Otsu (1973).

Many of the reports on baitfishes are mostly from brief observations or findings that were of a cursory nature with some related project being the primary interest. The purpose of this report is to bring together existing information on baitfishes that will hopefully provide essential background data for future investigations and serve as a useful aid for the development of island fisheries.

Biological data on baitfishes related to capture, confinement, handling, and use in pole-and-line fishing for skipjack tuna is, with several exceptions, inadequate and fragmentary. More detailed investigations have been conducted on important bait species, especially anchovies such as the nehu, *Stolephorus purpureus*; anchoveta, *Cetengraulis mysticetus*; Japanese anchovy, *Engraulis japonicus*; and the northern anchovy, *E. mordax*. Additional studies have been completed or are in

progress on other species that include tilapia, *Tilapia mossambica*; Japanese sardine, *Sardinops melanosticta*; threadfin shad, *Dorosoma petenense*; milkfish, *Chanos chanos*; and two topminnows, *Poecilia vittata* and *P. mexicana*.

Baitfish surveys have been conducted in central and western Pacific areas to identify existing species and to determine their potential value to the fishery. The areas under recent study include New Caledonia, New Zealand, Fiji, Marshall Islands, Samoa, Palau, New Guinea, Bismarck Sea, Ryukyu Islands, and Hawaii.

METHODS

Although useful studies on many species will no doubt provide important biological and technical data, this information has been excluded unless directly applicable to pole-and-line fishing. Also excluded are numerous fishes listed as observed or captured during a baitfish survey but not representing a bait resource. Many species listed by Nakamura (n.d.), Kikawa (1971), Grandperrin and Fourmanoir (1972), Kearney et al. (1972), and by Lewis et al. (1974) are of scientific interest but offer little practical value as live bait for tuna fishing. No doubt many reef fishes throughout the Pacific have been used successfully as bait without being recorded in literature. For example, species such as *Apogon brachygrammus* (Apogonidae), *Saurida gracilis* (Synodontidae), and *Asterropteryx semipunctatus* (Eleotridae) were observed in baitwells of Hawaiian tuna boats, having been taken incidentally during seining and night lighting for nehu. Such occurrences are not sufficient to establish them as baitfishes in the true sense of the word. They are captured by chance when fishermen

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are in pursuit of other bait species and are used as chum accordingly.

All small fishes that are associated with coral reefs can be used as bait, but they are sparsely scattered and it is difficult to take them in large quantities (Anonymous 1937a). There is no special selection in the Minicoy Island fishery, Laccadive Archipelago, where all small reef fishes are captured and used as chum (Jones 1958). Kikawa (1971) noted that it is important to use as many species as possible to establish a more stable bait fishery.

Data included in the discussion of each family and recorded in Tables 1 and 2 are not meant to imply that additional information is not extant. Only those references that were accessible or were considered pertinent are included. It is reasonable to assume that some useful species have been inadvertently omitted.

Larval fishes and eels were used as chum for skipjack tuna by the Japanese (Imamura 1949). The general use of vernacular names in this and a similar study (Anonymous 1937a) leaves some degree of doubt as to the correct identification of many species. In cases where specific identifications could not be determined, they were omitted. In the English synopsis, Far Seas Fisheries Research Laboratory (1969:170), juvenile squirrelfishes (Holocentridae) were reported as being captured by night lighting in the Bismarck Sea area but they were considered too small for use as chum. Suda (1972) noted the use of mini-samna, *Cololabis saira?*, as live bait for tuna—a species commonly used as longline bait. The sand lance (Ammodytidae) was supposedly used in Japan to some extent as a live baitfish (U.S. National Marine Fisheries Service, 1972). A report (Anonymous 1937a) noted that filefish were caught at Saipan along with other reef fishes as live bait for tuna.

Kearney et al. (1972) briefly noted that flyingfishes (Exocoetidae) may be of possible importance as bait for tuna in Papua New Guinea. No additional comments were made but seven species were noted in the appendix (p. 134).

In the text which follows, the families are treated alphabetically. Under each family listed in Tables 1 and 2 the baitfishes are arranged alphabetically by genus and species. Only current names have been used and no taxonomic changes or new distributional records included.

The various descriptive categories in Table 1 were selected in an effort to be explicit and to include only those that would contribute to a better understanding of baitfish biology and behavior as applied to pole-and-line fishing. The sequence does not indicate relative importance.

Body Length

Two size groups are included, 1) 2.5-7.5 cm and 2) 7.5-15.2 cm total length. Since the use of live baitfishes over 15.2 cm (6 in) in length is rare, a larger size range was excluded. Many species reach a size greater than 15.2 cm and in these cases it is the juveniles that are used as live bait. Some reports noted that the young, juveniles, or

small sizes were used without giving specific information. In most cases the species in question was placed in one of the two size groups. The data included in Table 1 for each species are referable to that specific size range indicated under column A.

Body Form

Body shapes represented by baitfishes successfully employed as bait suggest that this particular characteristic is not critical. The greatest number of bait species occurs in group number 1, which includes elongate forms ranging from larval eels (Imamura 1949) to some species of *Sardinella* that have a moderately deep body, almost approaching a perchlike form. The second group, the oblong or perchlike body form, appears second in frequency while the deep-bodied forms appear last. Body form invariably changes with growth even within a particular size group. The body shape most frequently encountered when used as bait is indicated in column B. Since most have compressed bodies that may differ slightly, it was considered impractical to separate individuals on this characteristic. Species notably compressed such as some of the Clupeidae and Carangidae are indicated by a number 4.

Body Coloration

A silvery color and elongate body have most often been considered important baitfish requirements since the greatest number of good baitfishes have these characteristics. Some generalizations can be made relative to coloration, but specific data are lacking concerning the attractability and holding capabilities of one color or color pattern over another. The increased visibility of one baitfish over another may effectively attract more skipjack tuna to the fishing vessel. Successful fishing has been accomplished with fishes displaying a wide range of colors and color patterns. No attempt is made to evaluate species on this single characteristic due to the lack of data. The five groups listed in column C note coloration for a species when it was used as live bait. The five groups are: 1) silvery, 2) light, dusky, 3) medium dark to dark, 4) dark and light, and 5) bright colors.

Baitfish Behavior

Information within this category is meager due to the difficulties of obtaining accurate observations at sea by trained observers. Although four selections are available, the lack of entries is quite noticeable. It appears that movement by a live fish of a proper size is required for successful skipjack tuna fishing. The movement of a baitfish in relation to the vessel, its swimming motion, body movements, and reaction in the presence of a predator are important to the effectiveness of a bait species. The terms, 1) response to predator and 2) no response to predator, were included to emphasize that baitfish behavior in the presence of feeding skipjack tuna influences its effectiveness when chummed at sea. For

Table 1.—Compilation of biological data on live baitfishes used commercially, experimentally, or reported to represent a bait resource for capturing skipjack tuna, *Katsuwonus pelamis*, in the Pacific. (For explanation of categories A through G see pages 9-14.)

A. Body length	1 = 2.5-7.5 cm, 2 = 7.5-15.2 cm															
B. Body form	1 = elongate, 2 = oblong (perchlike), 3 = deep bodied, 4 = notably compressed															
C. Body coloration	1 = silvery (bright), 2 = light, dusky, 3 = medium dark to dark, 4 = dark and light, 5 = bright colors															
D. Baitfish behavior	1 = response to predator, 2 = no response to predator, 3 = schooling or "balling" around vessel, 4 = disperses, dives, sounds, or leaves vessel															
E. Schooling behavior	1 = schools at or near surface, 2 = schools at or near bottom, 3 = aggregates on or adjacent to reefs, 4 = disperses or solitary															
F. Survival in captivity	1 = good, 2 = fair, 3 = poor															
G. Baitfish evaluation	1 = excellent (high attraction rate), 2 = good (effective, suitable, successful, etc.), 3 = poor (low attraction rate)															

	A	B	C	D	E	F	G		A	B	C	D	E	F	G
ALBULIDAE (bonefish)								<i>Harengula thrissina</i>	—	3	1	—	1	—	—
<i>Albula vulpes</i>	1	1	1	—	1	2	1	<i>Herklotsichthys ovalis</i>	1, 2?	2	1	—	1	—	—
APOGONIDAE (cardinalfishes)								<i>H. punctatus</i>	1, 2	2	1	—	1	1	2
<i>Apogon notatus</i>	—	2	2	—	2	1	—	<i>H. schrammi</i>	1	2	1	—	—	—	—
<i>A. truncatus</i>	—	2	3,4	—	—	—	—	<i>Ilisha furthi</i>	—	2	1	—	1	3	3
<i>Apogon</i> sp.	1	2	—	—	3	—	—	<i>Konosirus punctatus</i>	—	3	1	—	—	—	—
<i>Archamia bleekeri</i>	1	2	—	—	—	1	2	<i>Lile stolifera</i>	—	2	1	—	—	—	—
<i>A. fucata</i>	—	2	2	—	3	—	—	<i>Neopisthopterus tropicus</i>	—	2, 4	1	—	—	—	—
<i>A. lineolatus</i>	—	2	2	—	—	1	—	<i>Opisthonema berlangai</i>	—	2, 4	1	—	—	—	—
<i>Cheilodipterus</i> sp.	—	2	—	—	—	—	—	<i>O. bulleri</i>	—	2, 4	1	—	—	—	—
<i>Rhabdamia cypselurus</i>	1	2	2	—	3	1	1	<i>O. libertate</i>	1, 2	2, 4	1	—	1	2	2
<i>R. gracilis</i>	1	2	2	—	—	—	2	<i>O. medirastre</i>	—	2, 4	1	—	—	—	—
ATHERINIDAE (silverside)								<i>Opisthopterus dovi</i>	—	2, 4	1	—	—	—	—
<i>Allanetta bleekeri</i>	—	1	1	—	—	—	—	<i>O. equatoralis</i>	—	2, 4	1	—	—	—	—
<i>A. forskali</i>	—	1	1	—	1	1	3	<i>Pellona ditchela</i>	2	2	1	—	—	—	2
<i>A. ovalaua</i>	1	1	1	—	1	1	2	<i>Sardinella clupeioides</i>	—	2	1	—	—	—	—
<i>A. valenciennei</i>	—	1	1	—	1	3	3	<i>S. fimbriata</i>	—	2	1	—	—	—	—
<i>A. woodwardi</i>	1	1	1	—	1	—	3	<i>S. immaculata</i>	—	2	1	—	1	—	—
<i>Atherinops</i> sp.	—	1	1	—	—	—	—	<i>S. jussieu</i>	—	2	1	—	—	2	—
<i>Hypoatherina tsurugae</i>	—	1	1	—	—	—	—	<i>S. leiogaster</i>	2	1	1	—	1	3	1
<i>Pranesus duodecimalis</i>	—	1	1	—	—	1	2	<i>S. marquesensis</i>	1, 2	2	1	3	1	1	2
<i>P. insularum</i>	1, 2	1	1	1, 3	1	1	1	<i>S. melanura</i>	2	2	1	—	1	—	—
<i>P. pinguis</i>	1, 2	1	1	—	1	1	—	<i>S. perforata</i>	—	2, 4	1	—	—	—	—
ARRIPIDAE								<i>S. sindensis</i>	—	2	1	—	—	—	—
<i>Arripis georgianus</i>	—	2	1, 5	—	—	—	2	<i>S. sirm</i>	2	1	1	—	1	1	2
BERYCIDAE								<i>S. stolefora</i>	—	2	1	—	—	—	2
<i>Beryx decadactylus</i>	—	3	1	—	—	—	—	<i>S. zunasi</i>	—	2	1	—	—	—	—
CARANGIDAE (jacks)								<i>Sardinops melanosticta</i>	2	1	1	—	1	3	1
<i>Atule djebada</i>	—	2	2	—	—	—	—	<i>S. neopilchardus</i>	1, 2	1	1	—	1	1	2
<i>Carangoides malabaricus</i>	—	3	1	—	1	—	—	<i>S. sagax caeruleus</i>	1, 2	1	1	1	1	2, 3	1
<i>Caranx</i> sp. (several)	1, 2	2	2	—	4	1	2	CYPRINIDAE (minnows, carps)							
<i>Caranx mate</i>	1	2	2	—	4	1	2	<i>Carassius auratus</i>	—	2	2, 3	4	—	1	3
<i>Chloroscombrus</i> sp.	—	2, 4	1	—	—	—	—	<i>Hypophthalmichthys molitrix</i>	—	2	2	4	—	1	3
<i>Decapterus</i> sp. (several)	1	2	2	—	1	—	2	<i>Notemigonus crysoleucas</i>	—	2	2	4	—	3	2
<i>Decapterus macrosoma</i>	—	2	1	—	—	—	—	DINOLESTIDAE							
<i>D. muroaji</i>	—	2	1	—	—	—	—	<i>Dinolestes lewini</i>	—	2	1	—	—	—	—
<i>D. pinnulatus</i>	2?	1	1	—	1	—	—	DUSSUMIERIIDAE							
<i>D. russelli</i>	—	2	1	—	—	—	—	(round herrings)							
<i>Megalaspis cordyla</i>	—	1	1	—	—	—	—	<i>Dussumieria acuta</i>	2	1	1	—	—	3	2
<i>Scomberoides lysan</i>	1, 2	2, 4	1	1, 4	4	2	2	<i>Etrumeus teres</i>	1, 2	1	1	—	1	3	2
<i>S. tol</i>	1, 2	2, 4	1	1, 4	—	—	—	<i>Spratelloides delicatulus</i>	1, 2	1	1	3	1	2, 3	1, 2
<i>S. tolo</i>	1, 2	2, 4	1	—	—	—	—	<i>S. gracilis</i>	—	1	1	—	1	2, 3	1, 2
<i>Selar crumenophthalmus</i>	—	2	2	—	1	1	1	<i>S. japonicus</i>	—	1	1	—	1	—	—
<i>Selaroides leptolepis</i>	—	2	2	—	1	—	—	ENGRAULIDAE (anchovies)							
<i>Trachurus</i> sp. (several)	—	2	2	—	—	—	—	<i>Anchoa arenicola</i>	—	1	1	—	—	—	—
<i>Trachurus declivis</i>	—	2	1	3	1	—	2	<i>A. compressa</i>	—	1	1	—	1	1?	2
<i>T. japonicus</i>	—	2	1	—	—	—	2?	<i>A. curta</i>	—	1	1	—	1	—	—
<i>Usacaranx georgianus</i>	—	2, 4	1	—	—	—	—	<i>A. exigua</i>	—	1	1	—	1	—	—
CHANIDAE (milkfish)								<i>A. ischana</i>	—	1	1	—	1	—	—
<i>Chanos chanos</i>	1	2	1, 2?	1	1	1	2	<i>A. lucida</i>	—	1	1	—	1	—	—
CICHLIDAE (cichlids)								<i>A. naso</i>	—	1	1	—	1	—	—
<i>Tilapia macrocephala</i>	—	2	2, 4	—	4	—	—	<i>A. panamensis</i>	—	1	1	—	1	—	—
<i>T. mossambica</i>	1	2	2, 4	2, 4	4	1	1, 2	<i>A. spinifer</i>	—	1	1	—	1	—	—
CLUPEIDAE (herrings, sardines)								<i>A. starksi</i>	—	1	1	—	1	—	—
<i>Clupea bassensis</i>	—	1	1	—	1	3	—	<i>Anchovia macrolepidota</i>	—	1	1	—	1	3	—
<i>Dorosoma petenense</i>	1	3, 4	1	1, 3, 4	1	2	2	<i>A. rastralis</i>	—	1	1	—	1	3	—

Table 1.—Continued.

	A	B	C	D	E	F	G		A	B	C	D	E	F	G
<i>Cetengraulis mysticetus</i>	1, 2	1, 2	1	—	1	1	1	MULLIDAE							
<i>Engraulis australis</i>	1, 2	1	1	—	1	2, 3	1, 2	(goatfishes, surmullets)							
<i>E. japonicus</i>	2	1	1	—	1	3	1	<i>Mulloidichthys</i> sp.	1	2	1	3, 4	1	2	—
<i>E. mordax</i>	2	1	1	—	1, 2	1	1	<i>Mulloidichthys auriflamma</i>	1?	2	1	—	1	—	2
<i>E. ringens</i>	1, 2	1	1	—	1	—	—	<i>M. samoensis</i>	—	2	1	4	1	—	2
<i>Lycengraulis poeyi</i>	—	1	1	—	4	—	—	<i>Parupeneus</i> sp.	—	2	—	—	—	—	—
<i>Scutengraulis mystax</i>	—	1	1	—	—	1	1	<i>Parupeneus pleurostigma</i>	—	2	2	—	1	2	—
<i>Stolephorus</i> sp.	1	1	1	1, 3, 4	1	3	1	<i>Upeneus</i> sp.	—	2	—	—	—	—	—
<i>Stolephorus bataviensis</i>	—	1	1	—	1, 2	—	1	<i>Upeneus tragula</i>	1	2	3, 4	—	—	—	—
<i>S. buccaneeri</i>	1	1	1	—	1, 2	1, 3	1	PEMPHERIDAE							
<i>S. commersoni</i>	1	1	1	—	—	3	—	<i>Parapriacanthus beryciformis</i>	—	3	2	—	—	—	—
<i>S. devisi</i>	1	1	1	—	1	3	1	PLECOGLOSSIDAE							
<i>S. heterolobus</i>	1	1	1	—	1	1, 3	1	<i>Plecoglossus altivelis</i>	—	1	2	—	—	—	—
<i>S. indicus</i>	—	1	1	—	1	3	1, 2	POECILIIDAE (topminnows)							
<i>S. purpureus</i>	1	1	1	1, 3, 4	1	3	1	<i>Gambusia</i> sp.	1	2	3	—	2, 4	1	—
<i>S. zollingeri</i>	—	1	1	—	—	—	—	<i>Gambusia affinis</i>	1	2	3	—	2, 4	1	—
<i>Thryssa baelama</i>	—	1	1	4	—	1, 2	2	<i>Poecilia</i> sp.	1	2	2, 3, 4	4	1, 2	1	3
<i>Thryssa setirostris</i>	—	1	1	—	—	1	—	<i>Poecilia latipinna</i>	1, 2	2	2	4	1, 2	1	—
GOBIIDAE (gobies)								<i>P. mexicana</i>	1	2	2	—	—	1	—
<i>Glossogobius giurus</i>	—	1	3	—	—	1	—	<i>P. sphenops</i>	1	2	2	—	1, 2	—	3
KUHLIIDAE (flagtails)								<i>P. vittata</i>	1	2	2	2, 3, 4	1, 2	1	2, 3
<i>Kuhlia sandvicensis</i>	1	2	1	3	1, 2	1	1	POLYNEMIDAE (threadfins)							
LABROCOGLOSSIDAE								<i>Polydactylus</i> sp.	—	2	2	—	1	—	2
<i>Labrocoglossa argenteiventris</i>	—	2	2, 5	—	—	—	—	<i>Polydactylus sexfilis</i>	1, 2?	2	2	—	1, 4	—	2
LEIOGNATHIDAE								POMACENTRIDAE (damselfishes)							
<i>Gazza minuta</i>	—	3	1, 5	—	1	—	3	<i>Abudefduf anabatooides</i>	—	2	3, 5	—	2, 4	—	—
LUTJANIDAE (snappers)								<i>A. coelestinus</i>	1	3	4	—	3	—	3
<i>Caesio coeruleaureus</i>	2?	2	5	—	—	1	1	<i>A. dicki</i>	—	3	3	—	3	—	—
<i>C. chrysozonus</i>	2	2	5	—	2	1	1	<i>Chromis caeruleus</i>	1?	3	3	—	3	1?	—
<i>C. diagramma</i>	—	2	5	—	—	—	—	<i>C. ternatensis</i>	—	3	3	—	3	—	—
<i>C. tile</i>	—	2	2, 5	—	—	—	—	<i>Dascyllus trimaculatus</i>	—	3	3	—	3	—	—
<i>C. xanthonotus</i>	—	2	5	—	—	—	—	<i>Pomacentrus pavo</i>	1	3	3	—	3, 4	—	2
<i>Gymnoaesio argenteus</i>	1	2	4	—	2	1	1	PRIACANTHIDAE (bigeyes)							
<i>G. gymnopterus</i>	—	2	5	—	—	—	—	<i>Priacanthus</i> sp.	—	3	2	—	3	1	—
<i>Lutianus vaigensis</i>	—	2	2	—	3, 4	—	—	PRISTIPOMATIDAE (salemas)							
<i>Pterocaesio pisang</i>	—	2	5	—	—	—	2	<i>Xenistius californiensis</i>	—	2	2, 4	—	3	—	—
MUGILIDAE (mullets)								<i>Xenocys jessiae</i>	—	2	2, 4	—	3	—	—
<i>Crenimugil crenilabris</i>	1, 2	2	1	—	1	—	—	SCOMBRIDAE							
<i>Mugil</i> sp. (several)	1, 2	2	1	—	1	1	—	(tunas, mackerels)							
<i>Mugil cephalus</i>	—	2	1	—	1	2	—	<i>Rastrelliger kanagurta</i>	1, 2	2	2, 3	—	1	—	—
<i>M. longimanus</i>	1, 2	2	1	1, 3	1	2	2	<i>Scomber japonicus</i>	—	2	2, 3	—	1	—	2
<i>M. trichilus</i>	1, 2	2	1	—	1	—	—	SPHYRAENIDAE (barracudas)							
<i>M. vaigiensis</i>	1, 2	2	1	—	1	—	2	<i>Sphyrna obtusata</i>	1, 2?	1	2	—	1	—	3
<i>Neomysx chapallii</i>	2	2	1	—	1	—	2	TETRAGONURIDAE							
								<i>Tetragonurus atlanticus</i>	1	1	3	3	1	1	2

example, the nehu, an excellent baitfish, was observed to dive but to return to the surface and exhibit marked dodging when pursued by feeding tuna (Iversen 1971). The two selections, 3) schooling or "balling" around the vessel and 4) disperses, dives, sounds, or leaves vessel, are terms used by various authors to describe baitfish behavior at sea.

Schooling Behavior

The four selections under this category are descriptive terms from various reports that relate to a particular bait species at time of capture. The entry in column E refers to that size group noted under column A. For more detailed information on a family or a specific baitfish consult the text since these groups are general in coverage.

Survival in Captivity

Terms describing survival were used in various reports of baitfishes in enclosures or during captivity aboard ship. Environmental conditions, capture and handling methods, live-bait well design, etc. all vary at time of capture and invariably influence survival of baitfishes. Frequently poor survival is due to overcrowding, rough handling, and substandard holding facilities. Juvenile anchovies and sardines are extremely delicate and regardless of treatment do not survive well in captivity. Lewis et al. (1974) reported that loading of night-captured baitfishes during daytime significantly reduced mortalities. An improved understanding and application of the basic requirements of baitfishes in captivity will improve survival in most cases.

Table 2.—Geographical location of the use of live baitfishes commercially and experimentally or representing a bait resource for capturing skipjack tuna, *Katsuwonus pelamis*, in the Pacific. (For explanation of geographical areas see page 14 and Figure 1.)

1. Eastern Pacific (includes Revillagigedo, Clipperton, Cocos, and Galapagos Islands)
2. Marquesas, Tuamotu Archipelago, Society, and Austral Islands
3. Line Islands
4. Hawaiian Islands (includes Johnson and Midway Island)
5. Phoenix, Tokelau, Samoan, Ellice, Fiji, and Tonga Islands
6. Marshall and Gilbert Islands
7. Mariana and Caroline Islands (includes Saipan, Guam, Palau, Yap, Truk, and Ponape)
8. New Guinea, New Caledonia, Admiralty, Solomon, New Hebrides, Santa Cruz, and Loyalty Islands.
9. Australia (Queensland, New South Wales, Victoria), Tasmania, and New Zealand
10. Philippine Islands, Celebes, Borneo, East Malaysia, and South China Sea
11. Japan, Ryukyu, Bonin, Volcano, Daito Islands, Taiwan, and North and South Korea
12. "South Seas"—A general term used by Cleaver and Shimada (1950) designating the area encompassed by the Japanese southern skipjack fishery.
13. Non-Pacific Ocean localities (not shown on map)

	1	2	3	4	5	6	7	8	9	10	11	12	13		1	2	3	4	5	6	7	8	9	10	11	12	13
ALBULIDAE (bonefish)														CLUPEIDAE (herrings, sardines)													
<i>Albula vulpes</i>					X									<i>Clupea bassensis</i>												X	
APOGONIDAE (cardinalfishes)														<i>Dorosoma petenense</i>			X										
<i>Apogon notatus</i>										X				<i>Harengula thrissina</i>	X												
<i>A. truncatus</i>										X				<i>Herklotsichthys ovalis</i>				X	X	X	X				X		
<i>Apogon</i> sp.							X	X						<i>H. punctatus</i>				X	X	X	X				X		
<i>Archamia bleekeri</i>											X			<i>H. schrammi</i>						X					X		
<i>A. fucata</i>										X				<i>Ilisha furthi</i>	X												
<i>A. lineolatus</i>								X						<i>Konosirus punctatus</i>											X		
<i>Cheilodipterus</i> sp.										X				<i>Lile stolifera</i>	X												
<i>Rhabdamia cypselurus</i>							X	X						<i>Neopisthopterus tropicus</i>	X												
<i>R. gracilis</i>					X									<i>Opisthonema berlangai</i>	X												
ATHERINIDAE (silverside)														<i>O. bulleri</i>	X												
<i>Allanetta bleekeri</i>										X				<i>O. libertate</i>	X												
<i>A. forskali</i>								X						<i>O. medirastre</i>	X												
<i>A. ovalaua</i>					X		X							<i>Opisthopterus dovi</i>	X												
<i>A. valenciennei</i>							X	X						<i>O. equatorialis</i>	X												
<i>A. woodwardi</i>							X			X				<i>Pellona ditchela</i>								X					
<i>Atherinops</i> sp.	X													<i>Sardinella clupeioides</i>											X		
<i>Hypoatherina tsurugae</i>										X				<i>S. fimbriata</i>											X		
<i>Pranesus duodecimalis</i>										X				<i>S. immaculata</i>											X		
<i>P. insularum</i>					X									<i>S. jussieu</i>								X					
<i>P. pinguis</i>					X	X	X	X						<i>S. leiogaster</i>							X			X	X		
ARRIPIDAE														<i>S. marquesensis</i>	X		X										
<i>Arripis georgianus</i>									X					<i>S. melanura</i>				X			X			X		X	
BERYCIDAE														<i>S. perforata</i>										X			
<i>Beryx decadactylus</i>										X				<i>S. sindensis</i>											X		
CARANGIDAE (jacks)														<i>S. sirm</i>				X			X						
<i>Atule djebada</i>										X				<i>S. stolefora</i>	X												
<i>Carangoides malabaricus</i>											X			<i>S. zunasi</i>											X		
<i>Caranx</i> sp. (several)					X	X				X				<i>Sardinops melanosticta</i>											X		
<i>Caranx mate</i>					X									<i>S. neopilchardus</i>									X				
<i>Chloroscombrus</i> sp.	X													<i>S. sagax caeruleus</i>	X												
<i>Decapterus</i> sp. (several)	X				X	X	X	X		X	X			CYPRINIDAE (minnows, carps)													
<i>Decapterus macrosoma</i>										X				<i>Carassius auratus</i>											X		
<i>D. muroaji</i>										X				<i>Hypophthalmichthys molitrix</i>											X		
<i>D. pinnulatus</i>				X				X						<i>Notemigonus crysoleucas</i>				X									
<i>D. russelli</i>								X			X			DINOLESTIDAE													
<i>Megalaspis cordyla</i>										X				<i>Dinolestes lewini</i>									X				
<i>Scomberoides lysan</i>				X										DUSSUMIERIIDAE (round herrings)													
<i>S. tol</i>					X					X				<i>Dussumieria acuta</i>					X					X			
<i>S. tolo</i>										X				<i>Etrumeus teres</i>	X		X										
<i>Selar crumenophthalmus</i>				X	X	X	X			X	X	X		<i>Spratelloides delicatulus</i>		X	X	X		X	X			X	X	X	
<i>Selaroides leptolepis</i>											X			<i>S. gracilis</i>				X		X	X			X	X		
<i>Trachurus</i> sp. (several)	X				X	X				X				<i>S. japonicus</i>										X	X		
<i>Trachurus declivis</i>									X					ENGRAULIDAE (anchovies)													
<i>T. japonicus</i>										X				<i>Anchoa arenicola</i>	X												
<i>Usacaranx georgianus</i>									X					<i>A. compressa</i>	X		X										
CHANIDAE (milkfish)														<i>A. curta</i>	X												
<i>Chanos chanos</i>				X	X					X		X		<i>A. exigua</i>	X												
CICHLIDAE (cichlids)														<i>A. ischana</i>	X												
<i>Tilapia macrocephala</i>					X									<i>A. lucida</i>	X												
<i>T. mossambica</i>					X	X					X			<i>A. naso</i>	X												

Table 2.—Continued.

	1	2	3	4	5	6	7	8	9	10	11	12	13		1	2	3	4	5	6	7	8	9	10	11	12	13
<i>A. panamensis</i>	X													<i>M. trichilus</i>				X									
<i>A. spinifer</i>	X													<i>M. vaigiensis</i>				X	X								
<i>A. sparksii</i>	X													<i>Neomysis chaptalii</i>					X								
<i>Anchoa macrolepidota</i>	X													MULLIDAE (goatfishes, surmullets)													
<i>A. rastralis</i>	X													<i>Mulloidichthys</i> sp.				X									
<i>Cetengraulis mysticetus</i>	X	X												<i>Mulloidichthys auriflamma</i>				X	X								X
<i>Engraulis australis</i>									X					<i>M. samoensis</i>				X		X	X						
<i>E. japonicus</i>											X			<i>Parupeneus</i> sp.											X		
<i>E. mordax</i>	X													<i>Parupeneus pleurostigma</i>				X									
<i>E. ringens</i>	X													<i>Upeneus</i> sp.											X		
<i>Lycengraulis poeyi</i>	X													<i>Upeneus tragula</i>											X		
<i>Scutengraulis mystax</i>										X				PEMPHERIDAE													
<i>Stolephorus</i> sp.					X		X	X						<i>Parapriacanthus beryciformis</i>											X		
<i>Stolephorus batauiensis</i>								X						PLECOGLOSSIDAE													
<i>S. buccaneeri</i>				X	X			X						<i>Plecoglossus altivelis</i>				X									
<i>S. commersoni</i>				X		X								POECILIIDAE (topminnows)													
<i>S. devisi</i>								X				X		<i>Gambusia</i> sp.				X									
<i>S. heterolobus</i>				X	X					X	X			<i>Gambusia affinis</i>					X								
<i>S. indicus</i>				X		X	X		X	X				<i>Poecilia</i> sp.				X									
<i>S. purpureus</i>			X											<i>Poecilia latipinna</i>				X									
<i>S. zollingeri</i>											X			<i>P. mexicana</i>					X								
<i>Thrissina baelama</i>				X			X							<i>P. sphenops</i>				X									
<i>Thryssa setirostris</i>							X							<i>P. vittata</i>				X									
GOBIIDAE (gobies)														POLYNEMIDAE (threadfins)													
<i>Glossogobius giurus</i>					X									<i>Polydactylus</i> sp.			X										
KUHLIIDAE (flagtails)														<i>Polydactylus sexfilis</i>				X									
<i>Kuhlia sanduicensis</i>				X	X									POMACENTRIDAE (damselfishes)													
LABROGLOSSIDAE														<i>Abudefduf anabatooides</i>											X		
<i>Labroglossa argenteiventris</i>											X			<i>A. coelestinus</i>							X						
LEIOGNATHIDAE														<i>A. dicki</i>											X		
<i>Gazza minuta</i>											X			<i>Chromis caeruleus</i>											X	X	
LUTJANIDAE (snappers)														<i>C. ternatensis</i>											X	X	
<i>Caesio coeruleus</i>								X		X	X			<i>Dascyllus trimaculatus</i>												X	
<i>C. chrysozonus</i>								X		X	X	X		<i>Pomacentrus pavo</i>							X						
<i>C. diagramma</i>									X					PRIACANTHIDAE (bigeyes)													
<i>C. tile</i>										X	X			<i>Priacanthus</i> sp.							X						
<i>C. xanthonotus</i>										X				PRISTIPOMATIDAE (salemas)													
<i>Gymnoaesio argenteus</i>							X							<i>Xenistius californiensis</i>				X									
<i>G. gymnopterus</i>								X						<i>Xenocys jessiae</i>				X									
<i>Lutianus vaigiensis</i>					X					X				SCOMBRIDAE (tunas, mackerels)													
<i>Pterocaesio pisang</i>								X						<i>Rastrelliger kanagurta</i>					X		X	X	X	X	X	X	
MUGILIDAE (mullets)														<i>Scomber japonicus</i>				X					X	X			
<i>Crenimugil crenilabis</i>			X	X							X			SPHYRAENIDAE (barracudas)										X	X	X	
<i>Mugil</i> sp. (several)				X	X									<i>Sphyræna obtusata</i>													
<i>Mugil cephalus</i>				X										TETRAGONURIDAE													
<i>M. logimanus</i>			X	X	X									<i>Tetragonurus atlanticus</i>							X						

Baitfish Evaluation

Information on the success of various species for attracting and holding skipjack tuna was taken from reports and is not my evaluation. The three selections in this category are general terms since many reports were of a very general nature. For more specific information than is given in Table 1, see the appropriate text section and citation.

A baitfish may be more successful on one occasion than on another. Suehiro (1938) reported that offshore skipjack tuna schools responded better to pole-and-line fishing than schools close to shore and that morning was the best time for fishing. Also, spring was a better time than autumn. The method in which the vessel approaches the school, type of natural food items in their stomachs, and the length of time since last feeding all affect skipjack tuna response to fishing. It was noted by

Uda and Tsukushi (1934), Aikawa (1937), and Sasaki (1939) that there is a seasonal difference in the response of skipjack tuna. Also, oceanographic conditions, density of the skipjack tuna school, and relation of the school to birds, floating logs, sharks, or whales may affect their response to live bait. Strasburg and Yuen (1960) described a "feeding frenzy" in which tuna indiscriminately fed on any small object in the water. Strasburg (1961) observed that diving schools were difficult to attract with live bait. Even after fishing had begun, it was often interrupted by the school periodically diving. Yuen (1962, 1969), Kearney et al. (1972), and Lewis et al. (1974) reported a difference in the response of skipjack to live bait that was apparently associated with the vessels' water spray system.

A description of the different types of tuna schools and associated terminology is given by Scott (1969) and Lewis et al. (1974) and a review of field observations on

tuna behavior by Nakamura (1969). Studies on the nehu indicate that approximately 50% of the skipjack tuna schools chummed in Hawaiian waters do not respond to chumming. The time of day, weather conditions, experience of the fishermen, and type of skipjack tuna school may influence the effectiveness of nehu. Yuen (1959) indicated that biting response was not affected by weather conditions or time of day. Factors related to biting response while fishing with nehu were the distance from land, skipjack tuna stomach contents, and whether skipjack tuna were feeding on fast-swimming or slow-swimming fishes.

The geographical areas outlined in Figure 1 are primarily for convenience in locating areas discussed in the text and recorded in Table 2. The numerical sequence in Table 2 is arbitrary and does not indicate political affiliations or importance as baiting areas. Although some faunal entities may be suggested in Figure 1, it is not intentional, but simply an aid for locating unfamiliar and remote places within an area as extensive as the Pacific Ocean. Since many Pacific bait species are wide ranging forms that have also been used in other areas, pertinent information on these outside the Pacific area has been included in the text. Many species not used in the Pacific Ocean for skipjack tuna but noted as being used elsewhere are not included (e.g., Labridae). For additional information on these see: Anderson et al. (1953), Rawlings (1953), Siebenaler (1953), Jones (1958, 1964a), Bane (1961), Raju (1964), and Thomas (1964).

BAITFISH FAMILIES

Albulidae

The bonefish, *Albula vulpes*, is not extensively used as a baitfish but juveniles were considered an excellent bait for pole-and-line fishing by June and Reintjes (1953). Young *A. vulpes*, 5.0 to 7.5 cm in length, are slender, elongate, and silvery. They school along sandy shores and on reef flats and are captured in seines during the day or by night lighting. Jones (1964a) noted this species is used in the Indian Ocean and small individuals are suitable baitfishes. They are usually captured in small numbers while seining for other species.

Apogonidae

Cardinalfishes are small, nocturnal, reef-dwelling fishes. They are widely distributed throughout the warm and temperate seas of the world and are noted to aggregate near coral reefs and coral heads. Their coloration is quite variable, many species displaying exotic colors and color patterns while some are drab in appearance. Because of their nocturnal habits and close proximity to coral reefs, catching sufficient quantities for fishing requires specialized techniques. These fishes are effective bait and are reported to be slow in movement (Anonymous 1937a). They were extensively used as live bait especially in the Ryukyu Islands (Cleaver and Shimada

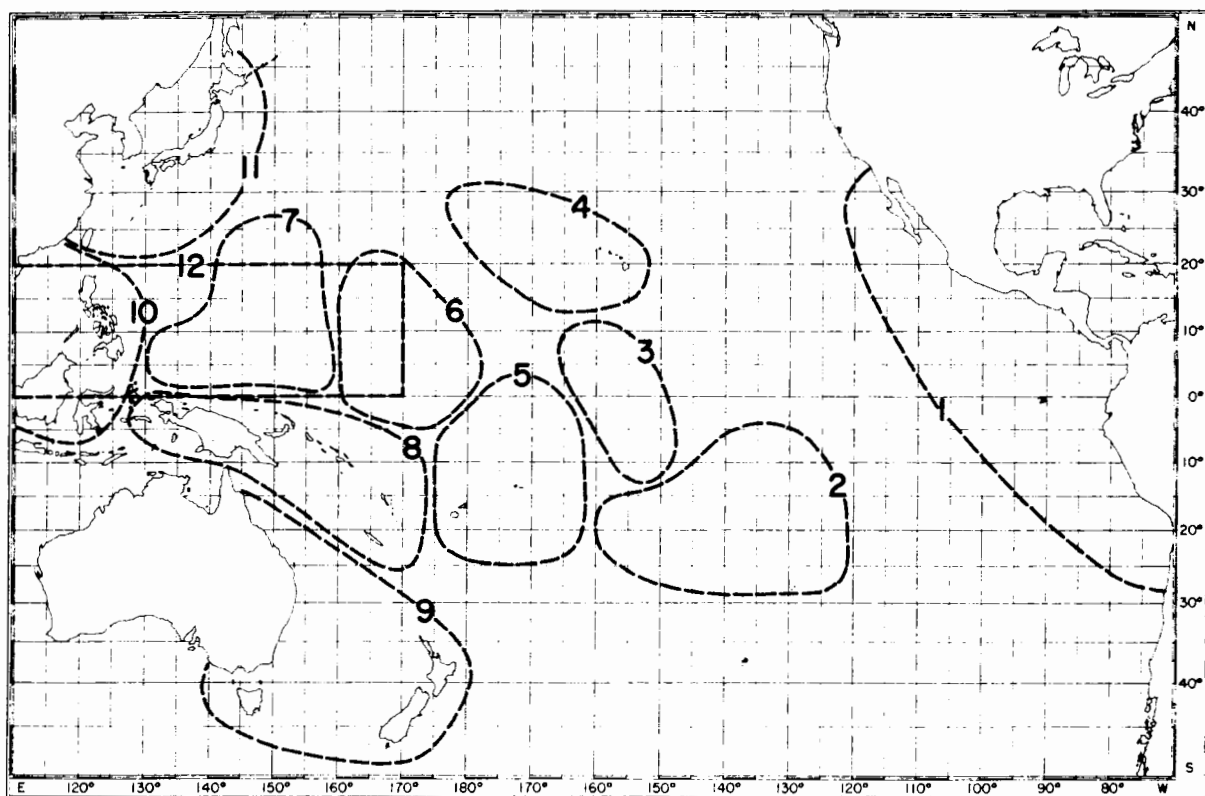


Figure 1.—Geographical location of the use of live baitfishes in the Pacific Ocean (see Table 2).

1950; Isa 1972), Palau (Anonymous 1937a; Wilson 1963), and Truk (Wilson 1963, 1971), while Jones (1964a) and Raju (1964) recorded their use in the Indian Ocean.

They are hardy and can be kept in confinement with reasonable care (Marukawa 1939; Jones 1964a; Wilson 1971). In Palau, cardinalfishes are excellent bait; they survive well aboard ship and are easily captured (Anonymous 1937a). They were noted to be present all year, especially between January and May, but their abundance fluctuates. Some preference for cardinalfishes by skipjack tuna was indicated in an unpublished report by Wilson,³ primarily from information obtained through Palauan fishermen. They said it was a better baitfish than *Spratelloides delicatulus* because it came to the vessel faster, remained longer, and had a lower mortality in the baitwells; but it is the least abundant of the live-bait species in Palau. Wilson (see footnote 3) noted that an average staghorn coral head yielded about five to six 4-gal buckets of live bait in 1 h. Two mo were required before the same coral head could be fished again and 4 to 5 mo before the population returned to normal.

In Truk, the akaesa, *Rhoddamia cypselurus*, is an excellent baitfish and second only to the takabe, *Gymnocaesio argenteus* (Wilson 1971). They form aggregations under coral heads and are captured with special nets at night. Details of this method and the drive-in net method of capture are given by Marukawa (1939), Shapiro (1949), Wilson (1971), Isa (1972), and Hester (1974).

Kearney et al. (1972), recorded three species captured by using night-lighting methods in New Guinea. They were: *R. cypselurus*, *R. gracilis*, and *Archamia lineolata*. Lewis et al. (1974) noted that *R. cypselurus* was a satisfactory and easily handled species, but not abundant. Jones and Kumaran (1964) noted that it is occasionally captured in appreciable numbers.

Rhoddamia gracilis, 4.1 to 5.9 cm, is used in Fiji as a baitfish but it is not important (Lee 1973).

Archamia bleekeri was reported to be hardy in confinement and effective as baitfish for skipjack tuna in the "south seas" (Marukawa 1939). Two additional species of *Archamia* of some importance are *A. lineolata* and *A. fucata*. The former was reported by Jones (1964a) to be the most important apogonid in the Laccadive fishery, but it exhibits rapid fluctuations in abundance. The latter species and *A. notatus* are important baitfishes in the Ryukyu Islands fishery (Isa 1972). The quantity of apogonids taken from three major localities in this fishery in 1966 and 1967 were 71.7 and 111.1 t, respectively. They were captured in a manner similar to that described by Wilson (1971) for the Truk fishery and occasionally by inserting tree leaves in the crevices and chasing the fish into a net. Cleaver and Shimada (1950) listed *Amia truncata* as used in Japan and the Ryukyu Islands fisheries without comment. This species is ap-

parently as synonym of *Apogonichthys poecilopterus* (Herre 1953).

Most cardinalfishes are reported to be abundant near reefs, especially around coral heads (Uchida 1970). Hida (1971) observed cardinalfishes around coral heads and scattered along the shallow reef in Micronesia, but it was impractical to capture them in sufficient quantity for a tuna clipper.

From the information available on cardinalfishes and their use as bait for skipjack tuna, it appears that most species are seasonal but can be used if found in quantity and in localities where they can be captured.

Atherinidae

Silverside are found throughout the warm Pacific and are generally considered hardy live baitfishes easily kept in captivity for extended periods. The various species are slender, silvery, and with moderately large scales that are firmly attached. They are found inshore along sheltered and semisheltered beaches, reef flats, in or near mangroves, or over sandy and mud bottoms. Capture methods include both beach seining and night lighting. The iao, *Pranesus insularum*, is the second most important baitfish in the Hawaiian fishery (Eckles 1949; Smith and Shaefer 1949; June 1951a; Ikehara 1953; June and Reintjes 1953). Although it is a good, hardy baitfish, seasonal fluctuations in abundance make it an unreliable source of bait (June and Reintjes 1953). Uchida and Sumida (1973) reported that when *P. insularum* is thrown as chum at sea it balls up and remains close to the vessel. Yuen (1961,⁴ 1969) noted silverside elicited less response from skipjack tuna than either *Caranx* sp. or nehu. It is hardier and generally larger than the nehu and subject to fewer injuries (Welsh 1950), but Hawaiian fishermen still prefer the nehu as live bait for skipjack tuna.

Uchida and Sumida (1973) reported fair to good quantities of *Pranesus pinguis*, 6.5 to 8.9 cm, at Majuro in the Marshall Islands. This species is a satisfactory baitfish and exhibits low mortality after handling. In Fiji, *P. pinguis* is hardy, vigorous, and withstands crowding with proper care (Lee 1973). This species and the sardine, *Herklotsichthys punctatus*, made up 81% of the 1972 baitfish catch in Fiji. Smith and Schaefer (1949) observed silverside (probably *P. pinguis*) along beaches and cliffs at Palau and it was the only species caught in quantity. Little information is available on the use of *P. duodecimalis* in the Philippine fishery (Domantay 1940a, 1940b) and in the Laccadive fishery, Indian Ocean (Jones 1964a). Jones (1964a) noted that it is hardy, occurs in shoals, and that this species and *Allanetta forskali* are the most dominant of four silverside.

Of the five species of *Allanetta* used for fishing skipjack tuna, only limited information on their use is

³Wilson, P. T. Undated. The bait resources of the Palau Islands. Mimeogr., 21 p. Hawaiian Tuna Packers, Ltd., Honolulu, HI 96809.

⁴Yuen, H. S. H. 1961. Experiments on the feeding behavior of skipjack at sea. Report presented at Pacific Tuna Biology Conference, Lake Arrowhead, Calif., August 1961, 6 p. U.S. Bur. Commer. Fish. Biol. Lab., Honolulu, HI 96812.

available. According to Wilson (see footnote 3) the teber, *A. woodwardi*, with an average length of 4.96 cm, is quite hardy. In Palau it is not necessarily a good baitfish since skipjack tuna seemed to prefer other species. Hooks baited with teber were less effective than hooks baited with mekebud, *H. punctatus*. It is present all year in brackish water and seawater habitats; it is not attracted to night lights. Wilson (1971) noted that it is a poor baitfish at Truk and not found in commercial quantities. It is not important in the Ryukyu Islands fishery (Isa 1972), although it is used to some extent. *Allanetta forskali* is used less than other forms of *Allanetta*. Jones (1964a) noted that in the Laccadives it occurs in schools and is hardy. Kearney et al. (1972) reported that silverside were second in abundance to anchovies with *A. forskali* and *A. valencienni* being the most common in Papua New Guinea. They were attracted to lights and easy to handle, but they were not very successful in attracting skipjack tuna. Marukawa (1939) noted that *A. valencienni* was seldom used, however, they were considered a good, but delicate, baitfish in Palau (Anonymous 1937a). June and Reintjes (1953), Wilson (1971), and Lee (1973), reported *A. ovalua* is relatively hardy and can be easily carried on vessels. It is rarely captured in large numbers in the Phoenix Islands (June and Reintjes 1953). In Truk, Wilson (1971) noted that it is used only when other bait species are not available. Lee (1973) listed *A. ovalua* (4.7 to 8.0 cm) as one of the important bait species in Fiji. *Allanetta bleekeri* is listed by Cleaver and Shimada (1950) as having been used as live bait in the Japanese and the Ryukyu Islands fisheries along with *Hypoatherina tsurugae*.

Silverside reported as *Atherina* sp. from Pacific localities can be more correctly listed as *Pranesus* or *Allanetta* since the former genus is restricted to European species (Schultz 1948). The only eastern Pacific silverside reportedly used as live bait is *Atherinops* sp. (Alverson and Shimada 1957).

Arripidae

The young of one species of this family, *Arripis georgianus*, was noted by Sampson (1962) as being successfully used for live bait in Australia. It is an elongate, compressed fish with large scales and reported to reach an average length of 22.8 to 25.3 cm. The juveniles have a series of golden bars that disappear with age.

Berycidae

Considering the fact that members of this genus are known to be deep-sea fishes, the record of *Beryx decadactylus* being used in Japan and the Ryukyu Islands as live bait for skipjack tuna (Cleaver and Shimada 1950) appears questionable.

Carangidae

None of the carangids listed appear capable of

supplying the annual quantities of baitfishes required by a pole-and-line fishery. They are predominantly silver, some species having dark bars, and the body is compressed and quite variable in shape. Only the juveniles are used and they are most often captured with night lights and lift nets or with drive-in nets inshore over a sandy bottom. Occasionally limited numbers are captured in bait seines during the day along with other species. They are available on a seasonal basis, hardy, and effective in attracting skipjack tuna.

Sea tests using *Trachurus declivis* as a live baitfish were conducted in Australia (Flett 1944). They were captured with a "hood net" alongside the wharf at Eden, New South Wales. When "liberated" they immediately sought shelter under the vessel. Blackburn and Rayner (1951) tested *T. declivis* and *Sardinops neopilchardus* off New South Wales and reported good catches. Roughley (1966) described tests with young *T. declivis* that were captured in a lampara net at night. *Trachurus japonicus* was used as a live baitfish in the "south seas" (Marukawa 1939; Cleaver and Shimada 1950). Before the anchovy, *Stolephorus heterolobus*, was known to be abundant, *T. japonicus* was one of the principal baits for skipjack tuna (Marukawa 1939). They are captured at night using "fishing lights" and lift nets. An important carangid in the Saipan fishery is *Selaroides leptolepis* and it appears to hold about the same level of importance as *T. japonicus* (Marukawa 1939; Cleaver and Shimada 1950).

Alverson and Shimada (1957) listed *Trachurus* sp. as a miscellaneous baitfish infrequently used in the eastern Pacific fishery.

The genus *Decapterus* has been reported by various authors in several areas including the eastern Pacific, but little information appears to be available on its use. Imamura (1949) listed *D. muroaji* as being used in Japan, but made no additional comment. Isa (1972) listed *D. macrosoma* and *Selar crumenophthalmus* as being used as bait in the Ryukyu Islands fishery, with the latter the more important of the two. The quantity of both species used in this fishery from three major localities in 1966 and 1967 was 41.4 to 17.7 t, respectively. Cleaver and Shimada (1950) noted *D. russelli* was used by the Japanese fishery in the "south seas" and its use has been reported in Ponape (Anonymous 1937a, 1937b).

Decapterus sp. is a baitfish, reported by Ikebe and Matsumoto (1938), that is used in Saipan and usually captured during the day in dip nets with other bait species. These fish are found outside the reef where they sometimes school around vessels at anchor. Their season is irregular from June to September; they are not present every year. At Ponape the young of *Decapterus* were noted as being abundant in shallow areas where they are taken with drive-in nets (Anonymous 1937b). Lewis et al. (1974) considered *Decapterus* sp. as having the most potential among the carangids in the Papua New Guinea area, but this species and *Selar* sp. were not sufficiently abundant to critically evaluate. *Decapterus* sp. and *Selar* sp. appear in the lagoons of the Gilbert and

Ellice Islands at certain times, but night lighting did not attract sufficient quantities (UNDP/FAO 1969). A report by Welsh (1950) noted that young opelu, *D. pinnulatus*, and young akule, *S. crumenophthalmus*, were occasionally used in the Hawaiian fishery. These two plus two species of topminnows, *Poecilia sphenops* and *P. latipinna*, and the piha, *Spratelloides delicatulus*, made up about 1% of the total live-bait catch in Hawaii during 1947.

Juvenile *Caranx* evidently are not used as bait to any great extent, although occasional use was noted by Cleaver and Shimada (1950) and by Lee (1973). In Fiji, *Caranx* sp., 6.3 to 8.5 cm in length, are taken in small quantities while night lighting. Tests were conducted at sea in Hawaii by Yuen (see footnote 4; 1969) with *Caranx* sp.,⁵ *Kuhlia sandvicensis* (Kuhliidae), and *Pranesus insularum* (Atherinidae). The attack rate by skipjack tuna was greater with the vessel's water spray on during chumming with *Caranx* sp. and *K. sandvicensis* than when turned off. Yuen (see footnote 4) also noted that when *Caranx* sp. was tested in alternate periods with *P. insularum*, *Caranx* sp. elicited a greater response. Hida (1971) reported jacks, mostly *Caranx* sp., common in Micronesia in the shallows close to shore or occasionally along the lagoon dropoff, but they were not found in large concentrations.

The most widely used carangid baitfish is the bigeye scad, *Selar crumenophthalmus*. The young appear inshore in large schools seasonally where they are captured in surround nets, set nets, or by using night lights. In Saipan the season is from June to September and they are considered suitable bait for medium and large skipjack tuna (Ikebe and Matsumoto 1938). Uchida and Sumida (1973) observed juveniles along the beaches in American Samoa but not in large quantities. In Fiji they are captured by night-lighting methods and considered hardy (Lee 1973). They are also used in the Philippine fishery (Domantay 1940a), in the "south seas" (Marukawa 1939; Imamura 1949; Cleaver and Shimada 1950), and in the Ryukyu Islands (Isa 1972).

Three species of leatherbacks (genus *Scomberoides*) have been used as live baitfish for skipjack tuna. They include *S. tol* reported by Lee (1973) in Fiji; *S. lysan* reported by June and Reintjes (1953) in Hawaii; and *S. tolo* used in the Philippine fishery (Domantay 1940a, 1940b). According to Smith-Vaniz and Staiger (1973), *S. tolo* may be a synonym of *S. tala*. In Hawaii, the lae, *S. lysan*, is taken incidentally when seining for nehu. Large numbers of juvenile lae are frequently taken during the spring and summer. Hawaiian fishermen dislike the lae because of painful stings received from the sharp dorsal and anal spines, and they are considered a nuisance. In addition they prey upon nehu in the baitwells and are responsible for high mortalities when present in numbers (Halstead et al. 1972).

Marukawa (1939) reported that *Carangoides malabaricus* is an important baitfish in Saipan, and Cleaver and Shimada (1950) noted its use in the "south

seas." Additional carangids used as live baitfish include *Magalapsis cordyla* in the Philippines (Domantay 1940a, 1940b), *Atule djebada* in Japan and the Ryukyu Islands (Cleaver and Shimada 1950), and *Chloroscombrus* sp. in the eastern Pacific (Alverson and Shimada 1957). Small carangids called gatsun (probably *Atule djebada* or *Selar crumenophthalmus*) were a principal baitfish at one time in Saipan (Marukawa 1939). Wherever small carangids are captured in sufficient quantity they can be employed successfully as a live baitfish for tuna. Their ability to attract skipjack tuna and to survive confinement in baitwells is relatively good.

Chanidae

Only small juvenile milkfish are of a suitable size for live-bait fishing. When obtainable, they are effective and quite hardy. The young are silvery, with elongate, compressed bodies. They form schools along beaches and reefs in shallow water where they are captured by seine.

Yuen and King (1953) reported catching yellowfin tuna, *Thunnus albacares*, in the Line Islands with live bait that consisted of mullet (species unknown) and juvenile milkfish, *Chanos chanos*. Warfel (1950) reported young milkfish as a suitable baitfish in the Philippines. Since milkfish are in demand as a food fish, the price is usually excessive for economical use as live bait. Tests at sea demonstrated they were easy to handle, schooled well in the bait tanks, and were attractive to tuna. The satisfactory size was noted as being around 35 to 44 milkfish per kilogram.

Juvenile milkfish may be of value in the future as a live baitfish if techniques for producing them economically and in quantity throughout the year are developed. There is a possibility of culturing milkfish in Fiji (UNDP/FAO 1969) and Sri Lanka (Samarakoon 1972) as a source of live baitfish.

Cichlidae

Several species of *Tilapia* have been introduced to Hawaii as an aid in controlling aquatic vegetation, as food fish, and as a possible source of live baitfish (Brock 1960). They are a hardy perchlike fish, with a deep, compressed body; the adult females are usually grey with dark vertical bands and the males black above. The young have several dark fin markings but generally resemble the adult female.

In Hawaii they are found in freshwater impoundments, stream mouths, and in bays and harbors in seawater. *Tilapia mossambica* has received considerable attention as a possible baitfish for skipjack tuna, including studies of its culture potential (Brock and Takata 1955; King and Wilson 1957; Hida et al. 1962; Uchida and King 1962).

Extensive tests were conducted at sea with juvenile *T. mossambica* (Brock and Takata 1955; King and Wilson 1957; Hida et al. 1962; Shomura 1964; Yuen 1969). These tests demonstrated that tilapia is an effective baitfish

⁵Yuen (see footnote 4, p. 1) listed this species as *Caranx mate*.

but it is evidently not as good as the traditional nehu. Individuals larger than 2.5 cm tend to "sound" when chummed, while the small individuals stayed near the surface and swam along with the slowly moving vessel. King and Wilson (1957) and Hida et al. (1962) noted that tilapia were slow swimmers requiring a reduced vessel speed. They performed well on "wild" schools and were especially good for large skipjack tuna. When used as bait on skipjack tuna, tilapia elicit a hard-biting quality that is considered a very favorable reaction (King and Wilson 1957). No noticeable differences in the behavior of nehu and tilapia were reported when they were chummed alternately on the same school. During sea tests scuba divers followed tilapia and threadfin shad, *Dorosoma petenense*, to a depth of 23 m before discontinuing the pursuit (Iversen 1971). This diving behavior by tilapia over 5 to 6 cm in length may not be detrimental to the taking of hard-biting skipjack tuna schools (King and Wilson 1957).

Shomura (1964) suggested designing an artificial lure specifically for use with tilapia since the standard nehu lure used in Hawaii may not be completely suitable. Sea tests conducted in 1958 and 1959 (Anonymous 1960) demonstrated successful use of juvenile tilapia in Hawaiian waters. In 1958 and 1959 the average catches per pound of tilapia live bait were 46 and 92 pounds, respectively, of skipjack tuna. For the same years the average catch rates using nehu were 50 and 57 pounds, respectively.

The importance of *Tilapia mossambica* as a live baitfish in the Laccadive fishery, Indian Ocean, was reported by Jones (1964b). It was introduced into ponds on Minicoy Island as a supplementary baitfish to be used when natural baitfish supplies were scarce.

Culture of *T. mossambica* as a live baitfish was considered worthwhile in American Samoa by Villaluz (1972) and in Fiji (UNDP/FAO 1969).

Clupeidae

Clupeids are used throughout the Indo-Pacific as live baitfishes for skipjack tuna. Of the 30 or more species reportedly used, all apparently have a high attraction rate for skipjack tuna. They resemble each other closely and separation of the various species is usually difficult. They are schooling fishes, silvery in color, with a compressed, elongate to moderately deep body usually lacking prominent markings. Juveniles less than 7.5 cm in length are undoubtedly used, but sizes from 7.5 to 15 cm are in demand.

They are reasonably hardy if handled with care and survival rates range from good to poor. It is difficult to assign a relative "hardiness" rating to most species due to the number of variables associated with their capture, handling, and subsequent confinement. Although many factors related to their confinement aboard ship influence survival, baitwell mortalities also reflect the degree of injury and scale loss received during capture and loading.

Baitfish size may also affect survival, as indicated by Anderson et al. (1953). They noted that small thread herring, *Opisthonema libertate*, are hardier than large individuals. Ikebe and Matsumoto (1938) stated that a baitfish should be selected first for its desirability and secondly for its hardiness, and that the best baitfishes are fat sardines 6 to 9 cm in length. It was observed that lean baitfishes are more subject to injury and stress than fat baitfishes. Cleaver and Shimada (1950), in reference to *Sardinops melanosticta* and the Japanese anchovy, *Engraulis japonicus*, stated that small fish are more resistant to the effects of confinement although they are more liable to injury from handling. They concluded that the most desirable baitfish size is from 7.5 to 12.5 cm and that small fish are as attractive to skipjack tuna as larger fish and a greater number can be carried in the baitwells.

Species such as *Clupea bassensis* and *Sardinops neopilchardus* from southern Australia represent future baitfish resources in that area (Flett 1944). Sampson (1962) noted that *S. neopilchardus* is the next most difficult baitfish species to keep with *Engraulis australis* (Engraulidae) being the most difficult. An interesting note by Roughley (1966:213) briefly mentioned successfully substituting small brass cylinders in place of live pilchards, *S. neopilchardus*, when fishing tuna in Australia.

Baitfish surveys conducted in 1970 and 1972 provide considerable detail of the Japanese method of bōuke net fishing for pilchard, *S. neopilchardus*, and anchovy, *E. australis*, in New Zealand (Webb 1972a). Webb noted that the best temperature for bōuke netting pilchard was 15°-19°C and that pilchard were too lively or did not surface at higher temperatures. If predators were present, the baitfish were scary; if too deep, the baitfishes would not be attracted to the light. In addition, the weather had to be favorable with a light breeze of 0 to 10 kn and a calm water surface. The baitfish survived from 3 to 8 days in the baitwells. Although there were quantities of pilchard in the area, bōuke net fishing was considered unsuccessful. In Tasmania, difficulties were experienced when night lighting pilchard because predators disrupted the concentrations of baitfishes (Anonymous 1951).

Webb (1972b) described in detail a bait fishing survey in the Marlborough sounds, New Zealand, using purse seining gear. Webb noted that altering engine or propeller speed when setting the seine caused the baitfishes to scatter. The best method of seining at night was to leave the lights turned off until just prior to setting the net. Baitfishes were observed to concentrate near the light soon after it was turned on and then to gradually disperse.

Bait was kept in holding pens for 5 days or more before being loaded aboard the fishing vessel to allow time for the baitfishes to acclimate and the weaker individuals to die off. Apparent panic or stress behavior by the baitfishes was due to overcrowding, presence of predators, confining nature of the purse seine, or to sudden flashes of light. Also, among newly caught baitfishes, this behavior was caused by vessel vibration, vessel motion.

lighting, and variable sea temperatures. Mortalities in the holding pens ranged from 3.5 to 17%, averaging 10.6%. During the survey the best bait catches were made at night, with 85% of the bait being captured during hours of darkness.

Webb (1972b) also observed that following each storm, baitfishes were absent from shallow waters and were located by an echo sounder at depths below 27 m. They returned to shallower water following 24 to 36 h of calm weather. Additional observations were reported on the effects of precipitation, moon phase, presence of predators, and light intensity on capture. Schools of bait accumulated near the bait-filled pens, indicating that schools of captive bait attracted nearby concentrations. Webb (1972b) suggested that this attraction was caused by school noise from the captive baitfishes. Lewis et al. (1974) also used echo finders to locate, identify, and follow baitfish movements during night-lighting operations in New Guinea.

Kearney et al. (1972) listed three clupeids, *Pellona ditchela*, *Sardinella jussieu*, and *S. sirm*, as potentially useful baitfishes in New Guinea. The former species was noted by Lewis et al. (1974) to be an attractive baitfish in spite of its larger size.

Observations on baitfish resources were made in the western Pacific by Smith and Schaefer (1949). They reported the flat herring, *Sardinella* sp., in the Marshall Islands, at Truk, and at Palau, and noted that occasionally they were difficult to capture. At Palau the herring were wild and would dart under and around the bait seine or, when once surrounded by the net, they would jump over the corkline. Similar difficulties associated with capture were also noted by Peterson (1956) with *Harengula* sp. and with the thread herring, *Opisthonema libertate*, in Costa Rica. Wilson (1971) observed that the sardine, *Herklotsichthys punctatus*,⁶ was easily taken by day bait nets in Truk while Lee (1973) noted that *H. punctatus* and the anchovy, *Thrissina baelama*, were "skittish" when captured by night lift net. Kearney et al. (1972) observed that *H. punctatus* (reported as *H. ovalis*) was the most abundant and widely distributed clupeid in New Guinea waters and the only species of *Herklotsichthys* so far recorded there. According to Lewis et al. (1974) it occurs regularly and in quantity. Observations indicate it schools near the surface, shows erratic vertical movements, and appears to be a good baitfish.

Two species of the subfamily Dorosomatinae come within the scope of this report; the threadfin shad, *Dorosoma petenense*, used experimentally in Hawaii, and *Konosirus punctatus*, a commercial species used in the Ryukyu Islands. Although little information is available on *K. punctatus*, Isa (1972) reported that 1.0 and 6.8 t were captured in 1966 and 1967, respectively, from several localities in the Ryukyu Islands.

Tests at sea have demonstrated that threadfin shad is an effective live baitfish for skipjack tuna. Preliminary tests reported by King et al.⁷ demonstrated the effectiveness of shad when compared with nehu. The average size was 72 mm fork length, and the baitwell mortality during the test period was insignificant. Observers noted that they swam along with the vessel and skipjack tuna seemed to strike the shad more vigorously than the nehu, but the catch rate dropped off when shad were in use. A hypothetical explanation for this reduced catch rate was termed "instantaneous conditioning," in which the skipjack tuna would not respond as well to the nehu lure when shad was used. Strasburg (1959) observed a similar reduction in catch rate and attributed this to a "too-conspicuous" or a "too-active" baitfish.

On an exploratory cruise to the eastern Pacific shad were used quite successfully (Hida 1970a). They held up well during the 5-wk cruise and demonstrated their effectiveness as skipjack tuna bait. A subsequent report (Hida 1970b) noted high mortalities of shad while en route to Samoa from Hawaii, probably the result of rough seas during the 10-day trip.

A series of tests were conducted in Hawaiian waters (Iversen 1971), and shad were judged to have the ability to produce catches similar to the nehu. Iversen noted that shad were as effective as nehu in their ability to lure skipjack tuna to the vessel, to concentrate tuna at the fishing station, and to catch tuna. Underwater observations showed shad had a swimming behavior similar to the nehu, with some differences. The diving angle was usually 45° to 65°, not as steep as the nehu, and they did not swim as fast or dodge as vigorously. They are more visible underwater because of a deeper silvery body than the nehu. Both species were observed to dive but to return to the surface when pursued by skipjack tuna and to swim alongside the vessel. When followed by scuba divers, shad were recorded to dive to 23 m, at which depth the divers discontinued the pursuit (Iversen 1971). Supplies of threadfin shad were seined from a freshwater reservoir near Honolulu. They were then transported on trucks to Kewalo Basin for acclimation to seawater before being placed into baitwells.

Sea trials were conducted in Hawaii using threadfin shad or nehu simultaneously with a purse seine ([Hawaii.] Division of Fish and Game and Bumble Bee Seafoods [1970?]). Chumming directly from the purse seiner was unsuccessful as were experiments with drifting bait dispensers and chumming from a skiff. But working in cooperation with a commercial fishing vessel demonstrated that skipjack tuna can be captured using shad in a bait-purse seine operation. The shad were noted to swim away from the vessel or sound, and skipjack tuna did not take them as well as nehu, but successful fishing was reported when skipjack tuna schools were first attracted with nehu before chumming with

⁶I follow Whitehead (1964:273-284) in using *Herklotsichthys* as the generic name for all Indo-Pacific species of the family Clupeidae that were formerly placed in the genus *Harengula*. *Harengula thrissina* (Jordan and Gilbert) is an eastern Pacific form.

⁷King, J. E., D. W. Strasburg, H. S. H. Yuen, and P. T. Wilson. 1958. Introduction of threadfin shad to Hawaii and initial tests on its use as skipjack bait. Unpubl. rep., 8 p. Pacific Oceanic Fishery Investigations, U.S. Fish Wildl. Serv., Honolulu, HI 96812.

shad. They were considered a suitable supplementary baitfish with a high rate of survival. A practical test with shad was conducted aboard the MV *Marlin* (R. T. B. Iversen, National Marine Fisheries Service, Honolulu, pers. commun.) but the overall catch rate was considerably less than that of other vessels fishing simultaneously and using nehu.

Techniques developed for capturing and handling threadfin shad are described by Iversen and Puffinburger (1977). Details concerning their introduction to Hawaii are given by Hida and Thomson (1962), and Shang and Iversen (1971) reported on the economics and culture feasibility.

The genus *Sardinella* (see Chan 1965) is represented by a dozen or more species used as live baitfish for skipjack tuna in the Pacific. The Marquesan sardine, *S. marquesensis*, is moderately abundant in the Marquesas area (Royce 1954; Anonymous 1957; Wilson and Rinkel 1957) and is thought to be effective as a live baitfish; however, Wilson and Austin (1959) believed the supply unreliable. Successful fishing was reported following a survey in the Marquesas and Tuamotus by the National Marine Fisheries Service research vessel *Charles H. Gilbert* (Anonymous 1957). Wilson and Austin (1957, 1959) reported Marquesan sardines form small schools, return to the vessel when chummed, and are quite suitable for skipjack tuna. They were captured in bays over a shallow sandy bottom and were attracted to lights. More sardines were attracted by a diffused light than by an intense light from a single bulb. They withstand crowding once acclimated to shipboard conditions and survive for extended periods.

The introduction of this species to Oahu, Hawaii, as a supplementary live baitfish was reported by Murphy (1960). Although it has successfully spawned in Hawaii and spread to the islands of Hawaii, Kauai, and Maui, it is not taken in any significant quantities by tuna fishermen (Hida and Morris 1963; Randall and Kanayama 1972).

The species of *Sardinella* that appear to be the most important as live bait include *S. leiogaster* (Anonymous 1937a; Marukawa 1939; Domantay 1940a, 1940b) and *S. melanura* (Domantay 1940a, 1940b; Wilson 1971; Hida 1973). Both species are satisfactory baitfishes and individuals 7.5 to 15.0 cm in length are the most desirable size for skipjack tuna. *Sardinella leiogaster* is considered to be hardy and a preferred species in the Philippines (Domantay 1940a, 1940b) while Marukawa (1939) considered this species fragile in the "south seas."

Little information is available on the remaining species of *Sardinella* as applied to pole-and-line fishing. Isa (1972) listed *S. sindensis* as commonly used in the Ryukyu Islands fishery and Lee (1973) noted that *S. sirm* is important in Fiji, while *S. stolefera* is occasionally used in the eastern Pacific (Schaefer 1963). Domantay (1940a, 1940b) noted *S. perforata* is used but not preferred in the Philippine fishery.

Wilson (see footnote 3; 1971), Hida (1973), Lee (1973), and Uchida and Sumida (1973) noted that *Herklotsichthys punctatus* has potential as a live baitfish in the Marshall Islands, Truk, Palau, and Fiji. Hida (1971) observed large schools ranging in size from hundreds of buckets to over 25 tons at Jaluit and Majuro Atolls, Marshall Islands. They school along the shore and are readily captured in seines during the day. Inamura (1949) noted that they concentrate in the shade of trees nearshore. They were not used in Palau by the Japanese and Okinawans since they grew too large for use on the smaller skipjack tuna of that area (Wilson see footnote 3). They are reasonably abundant in quiet, sheltered waters but move into deep waters at night and are occasionally known to completely disappear from some areas. Following World War II, Palauan fishermen preferred this species because it was not necessary to fish for them at night. It is attracted to lights and is considered to be a good baitfish, relatively hardy, easily transported, and lasting for several days under crowded conditions. Eighty-one percent of the baitfish catch in Fiji during 1972 was this species and *Pranesus pinguis* (Lee 1973).

Herklotsichthys ovalis is used as a baitfish in the Ryukyu Islands fishery (Isa 1972). This species plus *Sardinella clupeioides* and *S. sindensis* made up 7.8 and 4.8 t of clupeids captured from three major localities in 1966 and 1967, respectively. Ikebe and Matsumoto (1938) once observed a few *H. ovalis* about 12 cm long at Saipan. Large schools were later collected using night-lighting methods. Ikebe and Matsumoto (1938) noted that no baitfishes were available in Saipan from September to November except *H. ovalis* and an unidentified carangid. During these months both species were too large for skipjack tuna bait, but they would be useful as longline bait.

Following a baitfish survey in the Bismarck Sea by the Far Seas Fisheries Research Laboratory (1969), clupeids were noted to be one of the five dominant families with *H. ovalis* being the most common. Baitfishes were captured with an "above-water" or an "underwater" light that was dimmed shortly before the net haul was made. The lights were later switched to red lights which were more effective in concentrating the baitfish near the surface. The use of red lights during bōuke net fishing was also noted by Webb (1972a). Fishes considered suitable as to size, silvery color, and schooling habit were anchovies, round herrings, silversides, and herrings.

Ikebe and Matsumoto (1938) briefly noted that a few aoesa, probably *H. schrammi*, 2.0 to 2.2 cm were captured in Tanapag Harbor, Saipan. This fish was also taken at Woleai and Lamotrek Islands in the Carolines using a stick-held dip net (Matsumoto 1937). Herrings reportedly used in the eastern Pacific fishery include *Ilisha*, *Lile*, *Neopisthopterus*, *Opisthopterus*, and *Opisthonema*. They were usually caught incidentally or when more desirable bait species were scarce (Inter-American Tropical Tuna Commission 1952; Alverson and Shimada 1957). Anderson et al. (1953) noted that the

flat-iron herring, *Ilisha furthi*, did not survive well in captivity and was not commonly used.

One of the most important baitfishes in the Japanese fishery is the sardine, *Sardinops melanosticta*. It is used along with the Japanese anchovy, *Engraulis japonicus*, but reported to be less hardy (Suehiro 1936; Imamura 1949). Imamura (1949) reported that of the two species the former was more resistant to injury. In Japan a separate bait fishery sells live bait to the tuna vessels. When requiring a supply of live baitfish, a tuna vessel, by prior arrangement, purchases the bait needed before heading for the fishing grounds. Also, bait supply vessels carry quantities to the tuna boats on the fishing grounds (Cleaver and Shimada 1950). The advantages of this system include little loss of fishing time and a better quality of "aged" live bait. The techniques employed in the eastern Pacific fishery are described by Alverson and Shimada (1957), and in the Hawaiian fishery by June (1951b).

The Pacific sardine, *Sardinops sagax caeruleus*, has been used extensively as a live baitfish from California to the Galapagos Islands. In southern California and Baja California, it is captured with surround nets during summer and fall. Alverson and Shimada (1957) noted they were successfully transported aboard ship as far south as the Galapagos Islands. This species was reported as being superior to anchovies from the standpoint of attracting and chumming tuna but not as hardy (Anderson et al. 1953). In the Galapagos Islands they are captured from September through February and used throughout the islands and off the west coast of South America. It is a good baitfish and available during the fishing season in large numbers (Alverson and Shimada 1957). Capture is with surround nets or lampara nets, and in rocky areas it is necessary to have divers working underwater to "walk" the heavy headline over the bottom. Methods of capture and handling were described by Godsil (1938).

Cyprinidae

None of the minnows and carps listed in Table 1 have been used on a commercial basis as live baitfish for skipjack tuna. They have either been experimented with or they have received only cursory attention.

The silver carp or rengo, *Hypophthalmichthys molitrix*, has received some attention in Japan as a possible live baitfish (Anonymous 1972; Otsu 1973^a). Although the first reports were optimistic, later tests were disappointing. When only silver carp was used, skipjack tuna did not respond, and when silver carp was used with anchovies, the response was poor. It dives when chummed, and attempts to alter this behavior with salt water or chemicals before chumming were unsuccessful. It was found to be effective only when used as live bait on hooks (Otsu see footnote 8).

Another freshwater species tested in Japan was the common goldfish, *Carassius auratus* (Otsu see footnote 8). Tests at sea indicated it was sluggish in movement and not as effective as anchovies. It was deemed unsatisfactory and further tests were halted.

The golden shiner, *Notemigonus crysoleucas*, widely popular as a freshwater baitfish for recreational fishing in North America, was recently tested in Hawaii on skipjack tuna. Kato (1973)^b reported their physical appearance was suitable and sluggish individuals demonstrated behavioral patterns expected of a good baitfish. By placing them in 6‰ brackish water their activity decreased producing a sluggish behavior that may make them more desirable to skipjack tuna.

Dinolestidae

According to a single report by Sampson (1962), the long-tailed pike, *Dinolestes lewini*, was successfully used in Australia as a live baitfish for tuna. Apparently juveniles were used, but no additional information appears available. It is silvery with an elongate body and is reported to reach 50.8 cm in length.

Dussumieriidae

Round herrings are slender, elongate, silvery fishes, with deciduous scales that are easily lost during handling. They are delicate and must be handled with considerable care. Although weak, *Spratelloides delicatulus* and *S. gracilis* are important as live bait in areas where they occur in reasonable quantity. They are usually captured using night lights but they are also taken with bait seines and with drive-in nets, often incidentally with other species.

The makiawa, *Etrumeus teres*, and the piha, *S. delicatulus*, are considered by Hawaiian fishermen to be excellent baitfishes but fragile (June 1951a; Ikehara 1953; June and Reintjes 1953). They do not occur in sufficient numbers to be of importance as a baitfish in Hawaii but successful captures are occasionally made (Anonymous 1950a; Welsh 1950). *Spratelloides delicatulus* is the most widely used round herring in the Indo-Pacific. It is an excellent baitfish but does not survive well in captivity (Anonymous 1950b; Ikehara 1953; June and Reintjes 1953; Wilson 1971; Lee 1973), and it is seasonal with the greatest abundance occurring in the summer months (Welsh 1950; June 1951a; Wilson 1963). Summer and fall are usually the seasons for piha in Hawaii, where it is captured in the open seas off the southern coasts of most of the islands. Hida (1971) noted that it was abundant in lagoons of large atolls in Micronesia and aggregated under night lights. It is one of the important bait species found in Palau (Wilson see footnote 3). Its length ranges from 4.5 to 6.0 cm and it forms small, scattered schools in Malakal Harbor or in shallow inshore

^aOtsu, T. 1973. Trip report: Trip to Japan, February 3-22, 1973. Unpubl. rep., 20 p. Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.

^bKato, K. 1973. Baitfish project (interim report). Pacific Aquaculture Corp., Kihei, HI 96753. Unpubl. rep., 6 p. Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.

areas. It schools inshore and in adjacent deep water during the day and occasionally is observed far from land. It avoids muddy or dirty water and is captured by night lighting except during periods of full moon.

Prior to World War II when the Japanese fishery was established at Truk, it was an important baitfish especially from March to May when the more desirable takabe, *Gymnocaesio argenteus*, was scarce (Wilson 1971). Matsumoto (1937) reported that *S. delicatulus* is the most important baitfish at Saipan where it is found all year but is scarce in November and December. In January it was considered worthless as live bait and catching it was prohibited. At the peak of the season, one haul of the bait net captured enough for a day's fishing. It is not found in sufficient quantities in Saipan from September to February and is not good as a live baitfish during the spawning season in January (Wilson 1963). Jones (1960, 1964a) reported that it is seasonally available and is captured with night lights whenever possible for use as live bait in the Laccadive Archipelago.

Its behavior is typical of round herrings. It is a fast swimming, schooling fish attracted to lights, and when used as chum, it schools near the vessel. At times it schools so close that it is necessary to move the vessel forward to expose the bait to the tuna (Ikehara 1953). It is attractive to predators and has good catching qualities (Manar 1969).

Both *S. delicatulus* and *S. gracilis* are considered as possible baitfish resources in New Guinea by Kearney et al. (1972). Lewis et al. (1974) reported that both species are the most attractive baitfishes for skipjack tuna in waters of Papua New Guinea. Reduced mortalities were experienced by daylight loading of night-captured bait, but shipboard mortalities when crowding for chumming still are a problem.

In the Saipan and Tinian fisheries, *S. delicatulus* is a preferred bait species (Cleaver and Shimada 1950). A good baitfish size is 3.8 cm while sizes over 15 cm in length do not attract skipjack tuna as well. This species was reported abundant in Western Samoa (Van Pel 1960); no additional information is available.

Wilson (1971) noted that *S. gracilis* is a good live baitfish but not as hardy as *S. delicatulus* and not extensively used at Palau, while Lee (1973) noted that it is important in the Fiji fishery, but survival is poor.

Isa (1972) reported *S. japonicus* is an important baitfish in the Ryukyu Islands fishery. The quantity of round herrings, consisting of *S. japonicus*, *S. delicatulus*, and *S. atrofasciatus*, from three major localities in the Ryukyu Islands for 1966 and 1967 was 54.7 and 45.0 metric tons, respectively. Jones (1960, 1964a) noted *S. japonicus* is used in the Laccadive fishery and that it occurs in small schools but is not as abundant as *S. delicatulus*. Both species are seasonally available and have been observed on occasion in large quantities, but after December they are scarce (Thomas 1964).

Dussumieria acuta is used in the Philippine fishery (Domantay 1940a, 1940b) and in Fiji (Lee 1973). In Fiji it is used in lesser quantities than other available bait-

fishes because it is extremely fragile and does not survive for more than 6 h, but it occasionally produces good catches. The main drawbacks with this species are poor survival and seasonality of abundance.

A single species of round herring listed as *Etrumeus* sp. (probably *Etrumeus teres* according to Whitehead 1963) was used in the eastern Pacific fishery (Alverson and Shimada 1957). Additional observations on round herrings were made in the Tuamotus (Royce 1954), in the Tuamotus and Marquesas Islands (Anonymous 1955), and in Guam and Palau (Smith and Schaefer 1949).

Engraulidae

Throughout the Pacific Ocean, anchovies rank first in terms of quantity used, value, and general desirability as baitfishes. Their ability to attract and hold skipjack tuna, wide distribution, and occurrence in schools near-shore throughout the year contribute to their demand.

The majority of species are 12.5 cm or less in length with a silvery, elongate, compressed body, and with deciduous scales that are easily dislodged during handling. They range from quite delicate, as exemplified by the nehu (Struhsaker et al. 1975), to quite hardy, as reported by Alverson and Shimada (1957) and Bayliff and Klima (1962), for the anchoveta, *Cetengraulis mysticetus*.

Although many baitfishes are employed by the Japanese the two most important are *Engraulis japonicus* and *Sardinops melanosticta*. Of the two, the Japanese anchovy is the better baitfish since it can be kept more successfully than the sardine (Suehiro 1936) and is more resistant to oxygen deficiency (Cleaver and Shimada 1950). The most desirable size is 7.5 to 12.5 cm since small sizes are more resistant to death from confinement. Small baitfishes are as attractive to tuna as larger baitfishes and a greater number can be carried per unit of space. High mortality usually follows capture, handling, and confinement in holding enclosures and aboard ship (Anonymous 1971). They are usually held for 10 days to allow them time to "age," thus leaving the stronger individuals for tuna bait. Mortalities are highest in baitwells of the fishing vessel en route to the fishing grounds. A complete description of this fishery is given by Cleaver and Shimada (1950).

Baitfish surveys were conducted in Korea and Taiwan by the Japanese (Federation of Japan Tuna Fisheries Cooperative Associations and Japan Tuna Fisheries Federation 1972) to determine the resources of *E. japonicus* and the feasibility of transporting them to Japan to supplement their baitfish supplies. Observations indicate that they can be successfully captured in lift nets, a method superior to the lampara net method. Anchovies transported to Japan from Chungmu Harbor, Korea, had low mortalities when held in enclosures for 4 wk before loading them aboard the transporting vessel. Anchovies captured in Taiwan are of considerable value to the Japanese southern fishery since there is no need to transport them first to Japan.

The live bait and reduction fishery for the northern anchovy, *Engraulis mordax*, in California has developed into an important fishery in recent years (Messersmith et al. 1969; Wood and Strachan 1970; Spratt 1973). In addition to being used for tuna bait, the anchovy is of considerable value as live bait for recreational fishing. Quantities are captured by bait fishermen and then sold to sports fishermen, an operation resembling the Japanese bait fishery. Anderson et al. (1953) noted *E. mordax* is not as hardy as the anchoveta.

Engraulis mordax is taken in the same areas and used in the same manner as the Pacific sardine. Capture localities include southern California, Baja California, and the Gulf of California from June to November, and it is used almost exclusively on adjacent fishing grounds (Alverson and Shimada 1957). Methods of capture include purse seines and lampara nets described by Godsail (1938), Young (1949), and Wood and Strachan (1970).

Additional anchovies of the genus *Engraulis* include *E. ringens* used in the eastern Pacific fishery (Alverson and Shimada 1957), and *E. australis* reported by Flett (1944) from southeast Australia.

During exploratory fishing in Australia, *E. australis*, 7.5 to 8.8 cm, were captured with a submerged light and a "hoop net," and with a lampara net from different localities. They survived well and were freely taken by skipjack tuna but the catch rate was low. The majority of skipjack tuna were taken on hooks baited with live anchovies. On occasion they were observed to bite well perhaps due to rough seas that helped obscure the vessel and the fishing lines. The occurrence of *E. australis* in New South Wales fluctuates, although populations in Port Phillip Bay, Victoria, occur regularly during the skipjack tuna season. Sampson (1962) reported that individual *E. australis* are extremely prone to panic when captured and it is necessary to remain in port to allow the bait time to adapt to confinement. He notes that even after 2 days they may die faster than other species but were excellent bait for tuna. Additional information on capture, equipment, handling, and biology of *E. australis* is given by Webb (1972a, 1972b).

The most important baitfish in the eastern Pacific fishery for skipjack and yellowfin tunas is the anchoveta, *Cetengraulis mysticetus*. It is preferred because it is hardy, withstands crowding, and is tolerant to a wide range of water temperature. It survives for periods up to several months in captivity with low mortality (Anderson et al. 1953; Alverson and Shimada 1957). Its importance is emphasized by the fact that 40 to 60% of all the tuna landed in the eastern Pacific live-bait fishery each year were captured using this species for bait (Peterson 1956). A brief report by Mead (1949) on the capture of anchovetas at Macapule, Mexico, noted that bait was plentiful and easily located. Following a 3-day baiting period, 3,600 scoops of anchovetas were placed in the baitwells. They began milling immediately and mortalities were not excessive. Anchovetas have been successfully transported to the Marquesas and Tuamotus (Angot 1959).

The population of anchovetas in the Gulf of Nicoya, Costa Rica, declined in 1947 and subsequent transplanting of mature anchovetas from Panama to the Gulf of Nicoya was successful and the population was reported increasing. The biology of the anchoveta has been studied by Howard (1954), Howard and Landa (1958), Barrett and Howard (1961), Peterson (1961), Bayliff and Klima (1962), Klima et al. (1962), and Bayliff (1963a, 1963b, 1964, 1965, 1966, 1967).

Anchovies of the genus *Anchoa* are infrequently used as live bait for tuna in the eastern Pacific (Alverson and Shimada 1957; Schaefer 1962). They are less desirable than the anchoveta since they are not as hardy in captivity. The various species, usually under 12.5 cm in length, are difficult to identify and generally considered to be good baitfishes. *Anchoa compressa* was introduced to Hawaii in 1932 (Brock 1960) but this was unsuccessful. Additional anchovies used in the eastern Pacific include *Anchoa rastralis* and *A. macrolepidota*, but like the various species of *Anchoa* the quantities used are negligible and they do not live well in captivity.

Of the different species of anchovies listed, the nehu and the anchoveta have been studied more thoroughly than all the others combined. Anchovies of the genus *Stolephorus* occur throughout most of the tropical Pacific. The nehu, *S. purpureus*, is the primary bait species in Hawaii. It is captured in sheltered bays and harbors and tends to occupy habitats where fresh water enters the sea (Welsh 1950). A synopsis of the biological data on the nehu was compiled by Nakamura (1970). In 1947, 95% of the total baitfish catch in Hawaii was nehu. It is endemic to Hawaii,¹⁰ seasonally abundant, and considered delicate with mortalities following capture up to 25% per day.

Capture methods include day bait seining or with a night net. Causes of nehu mortalities were investigated by Brock and Takata (1955), Pritchard (1955), [U.S.] Bureau of Commercial Fisheries (1969), and Struhsaker et al. (1975). Recommendations on improved handling methods and live baitwell design were studied by Welsh (1950), Brock and Takata (1955), [U.S.] Bureau of Commercial Fisheries (1969), Baldwin et al. (1972), and Baldwin (1970, 1973a, 1973b). Details concerning the Hawaiian methods of capture, handling, and gear are described by June (1951a, 1951b) and by Yamashita (1958). Operational aspects of the Hawaiian fishery were investigated by Brock and Uchida (1968).

Nehu behavior, when used as chum at sea, was observed by King and Wilson (1957), Strasburg (1959), Strasburg and Yuen (1960), Shomura (1964), and Iversen (1971). Strasburg (1959) and Strasburg and Yuen (1960) noted that when using dead nehu the skipjack tuna decreased their swimming speed, reduced the number of surface dashes, and fell astern of the vessel. When too many live nehu accumulated during chumming, small schools of skipjack tuna were noted to fall astern of the

¹⁰It is doubtful that records of *Stolephorus purpureus* from Saipan and Truk (Smith 1947) and from Guam (Van Pel 1956; Rothschild and Uchida 1968) are valid.

vessel. They reported that when insufficient numbers of nehu were chummed, skipjack tuna were observed to scatter perhaps due to an "insufficient feeding stimulus." When the water spray was off, the skipjack tuna reduced their swimming speed, swam deeper, and made fewer surface dashes.

Tests with monofilament gill nets were conducted in Hawaii (Shomura 1963) while chumming with live nehu. The results indicated this method was not as effective as the pole-and-line technique. Underwater observations made on nehu and shad (Iversen 1971) noted both species tend to dive but nehu appeared to dive faster and exhibit marked dodging. Both returned to the surface when pursued by skipjack tuna and were observed to flee to the side of the vessel and swim along with it. Iversen (1971) noted that their swimming behavior was similar and both were observed to dive to a considerable depth. Yuen (1969) found skipjack tuna responded better to live than dead nehu in catch rate, rate of attack by tuna, and in the numbers of tuna attracted to the vessel. The catch rate also increased when the vessel's water spray was in operation and nehu were more effective than juvenile tilapia.

The roundhead, *Stolephorus buccaneeri*, is occasionally observed in schools offshore but is of little importance to the Hawaiian fishery. It is occasionally mixed with *S. purpureus* (Matsui 1963). It is a pelagic species and, according to Whitehead (1965), it has a wide distribution that was recently substantiated by Hida (1973). Kearney et al. (1972) reported that this species may prove to be important in New Guinea waters. They and Ronquillo¹¹ believed *S. buccaneeri* was frequently misidentified as *S. zollingeri* by others. Lee (1973) noted that *S. buccaneeri*, 4.7 to 8.5 cm in length, is an important and abundant live bait in Fiji. It is captured at night with other bait species, considered delicate, but will survive up to 2 days in captivity. The behavior and taxonomy of *Stolephorus* anchovies were studied by Lewis et al. (1974). They reported *S. buccaneeri* was an excellent baitfish with good handling qualities and tuna attractability but unfortunately its occurrence is unpredictable.

Stolephorus heterolobus was noted by Marukawa (1939) to be an excellent and hardy baitfish. It occurs along the shore in shallow water near mangroves and where fresh water enters the sea. Lee (1973) considered *S. heterolobus* delicate, requiring extreme care in handling. Although it is reported to be abundant at Yap, Caroline Islands, Ikebe and Matsumoto (1937) noted that it was difficult to capture by night lighting on moonlit nights. It is similar to the Hawaiian anchovy and appears to be seasonal in abundance (Anonymous 1937b; Smith and Schaefer 1949; Cleaver and Shimada 1950). Hida (1971) observed *S. heterolobus* at Ponape mostly in areas too deep for their shallow day seine; however, it was at-

tracted to night-lights. Smith (1947) reported schools of baitfish (probably *Stolephorus*) were attracted by lights and after a large school had assembled it was led to the bait net by moving the light.

Stolephorus indicus is used as a live baitfish at Ponape and Fiji (Lee 1973) and in the Philippine fishery (Domantay 1940a, 1940b), but like other members of this genus it is delicate. Lewis et al. (1974) reported *S. indicus* and *S. bataviensis* were not common during a survey in New Guinea and mortalities were high. They attain a larger size than other species of *Stolephorus* and are difficult to handle.

The remaining species of *Stolephorus* are not as important although *S. devisi* may represent a baitfish resource in the Solomon Islands; however, further testing is needed (Far Seas Fisheries Research Laboratory 1969). Kearney et al. (1972) noted *S. devisi* was the most abundant bait species captured under a night light in Papua New Guinea. It was an excellent baitfish but delicate and difficult to transport. They also noted that *S. bataviensis* was occasionally abundant and may represent a bait resource.

Lee (1973) reported that *S. commersoni* is fragile and does not live longer than 6 h in captivity, but gives good results on skipjack tuna in Fiji.

Read (1971) described the capture and use of *Stolephorus pseudoheterolobus* as a live baitfish in Palau. Ronquillo (see footnote 11) considered *S. pseudoheterolobus* to be a junior synonym of *S. heterolobus*. Isa (1972) noted that this species and *S. zollingeri* are used in the Ryukyu Islands fishery. The latter species is possibly *S. buccaneeri* as suggested by Kearney et al. (1972). Lewis et al. (1974) noted *S. heterolobus* and *S. devisi* are quite similar in their response to dimming the night-light when enclosed within the holding pen alongside the vessel. Both species are considered very good baitfishes, but *S. heterolobus* may be more attractive to tuna due to its metallic blue and silver color. These and other captive engraulids were reluctant to enter red or pink buckets that were later discarded in favor of blue buckets. A similar color preference by the nehu was observed by Struhsaker et al. (1975).

Of moderate importance in New Guinea and Fiji is *Thrissina baelama* (Lee 1973; Lewis et al. 1974). It is attracted to lights and is hardy, but it loses its scales easily and must be handled with care. This species and *Herklotsichthys punctatus* are "skittish" when captured with night-lights and a lift net. Lewis et al. (1974) noted *Thrissina setirostris* and *T. baelama* could be "dry scooped" into buckets with low mortalities, but *T. baelama* would leap out of the container when startled. The latter species was reported to swim rapidly away from the vessel when chummed, but, because it is hardy, further use of this species was suggested.

Gobiidae

Although there are no records of the white goby, *Glos-*

¹¹Ronquillo, I. A. Undated. An illustrated key to the genus *Stolephorus*, 2 p. [and] A review of the genus *Stolephorus*, with a key to species, 31 p. Manuscript on file at Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.

sogobius giurus, being used as bait for skipjack tuna, Villaluz (1972) considered its potential culture as a bait-fish worthwhile for American Samoa. The reasons for this selection are that *G. giurus* can survive under extreme environmental conditions and reproduces rapidly. It reaches a maximum length of about 30 cm, it is found naturally in fresh and salt water, but it is known to be cannibalistic.

Kuhliidae

A family of moderately common fishes found throughout the Indo-Pacific area. They are perchlike in appearance with an oblong, compressed body, silver color, and large eyes. Their size is usually under 30 cm. They are found in fresh, brackish, and saltwater habitats and are captured by seines during the day in shallow water nearshore. Since they are usually scattered or in small schools often over rough bottom and are not attracted to lights, capturing sufficient numbers requires too much effort to consider them as important bait species (Tester and Takata 1953).

The wholehole, *Kuhlia sandvicensis*, has been used as live bait for skipjack tuna in the Pacific. Jones (1964a) reported an additional species, *K. taeniurus*, that is used in the Laccadive Archipelago, Indian Ocean. It is hardy and found in fairly large numbers nearshore.

The young of *K. sandvicensis* make good live bait because they school when chummed and are readily taken by skipjack tuna (Ikehara 1953). However, their sharp dorsal and anal spines entangle in the nets and prick the chummer's hands. They were considered a satisfactory baitfish by June and Reintjes (1953) and Brock and Takata (1955), and will withstand long-distance transport if handled properly.

Sea tests conducted by Yuen (see footnote 4; 1969) with *K. sandvicensis* along with other species demonstrated that higher catch rates were made when the vessels' water spray was in use and this was independent of the attack rate by skipjack tuna. It was observed that they tend to dive when thrown as chum.

Tester and Takata (1953) concluded that because of its slow growth rate, late maturity, spawning difficulties, and problems related to egg retention and larvae; pond cultivation was not feasible.

Labrocoglossidae

Labracoglossa argentiventris, called takabe in Japan, is moderately elongate with a maximum size of 20 cm and common to central and southern Japan. Cleaver and Shimada (1950) briefly noted that this species was used as a baitfish in the Japanese fishery.

Leiognathidae

A single species of this family, *Gazza minuta*, has been used as a live bait for tuna (Marukawa 1939; Cleaver and Shimada 1950). It is a deep-bodied, compressed fish, reaching a maximum length of 14 cm and found in

schools in coastal waters. It is silvery with a pattern of orange and grey-blue lines on the upper sides. The Japanese capture it during the day with drive-in nets and at night with lights and a lift net. According to Marukawa (1939), it is not especially good as a live bait-fish since skipjack tuna do not take to them readily; however, it is used in localities where bait is scarce.

Kearney et al. (1972) listed the family Leiognathidae as having possible importance as a bait resource in Papua New Guinea.

Lutjanidae

Snappers are widespread throughout tropical and subtropical areas. Their body is typically fusiform-compressed and many species are brightly marked with blue and yellow. They are seasonal with the juveniles appearing in schools near reefs. Large schools of juvenile bananafishes (subfamily Caesioidinae) were reported outside the reef in Palau (Anonymous 1937a). It was thought that the occurrence of skipjack tuna schools nearshore was due to the abundance of this bait. They are an excellent baitfish, available in Palau from February to June. It is primarily the juveniles that are used for pole-and-line fishing (Marukawa 1939; Anonymous 1937a; Jones 1964a; Wilson 1971; Isa 1972; Kearney et al. 1972).

They are hardy and live well in captivity. Juveniles of such species as *Caesio chrysozonus*, 7.5 to 10.1 cm in length, are considered to be excellent baitfishes. Marukawa (1939) noted that juveniles, 7 to 10 cm in length, are used in the "south seas." They form large schools during the day and live in crevices and caves of shallow reefs. They are captured in lift nets at night and during the day with drive-in nets. Methods of capture are described by Shapiro (1949), Jones and Kumaran (1959), Wilson (1971), Isa (1972), and Hester (1974). They are extremely important in areas where anchovies are not available. Ikebe and Matsumoto (1938) mentioned that *C. chrysozonus* is most suitable for skipjack tuna bait, but that in Saipan it is seasonal and is not available every year. The season lasts only for several days, although enough can be obtained in one haul for several days of fishing. When available it is collected and held in hastily constructed ponds. Isa (1972) noted this species and *C. tile* were second only to the cardinalfishes in quantity in three major baiting localities of the Ryukyu Islands for the years 1966 and 1967.

Juveniles of *C. chrysozonus* and *C. coerulaureus* are valuable in the Laccadive fishery and occur in fairly large quantities throughout the skipjack season (Jones 1958, 1964a). Jones (1964a) noted that they are hardy, survive well, and are very effective. *Caesio coerulaureus* was the most important while *C. erythrogaster* was present only in small numbers. Jones and Silas (1963) noted that at Minicoy Island, *C. tile* is very effective but availability limits its usage.

Little information on the use of *C. coerulaureus*, *C. xanthonotus*, and *C. diagramma* in Japan, Okinawa, and the Ryukyu Islands is available. These species are simply

listed as being used as bait (Shapiro 1949; Cleaver and Shimada 1950).

The results of a baitfish survey in Papua New Guinea were reported by Kikawa (1971). Several methods of collecting were used including drive-in nets and night lighting with scoop nets and stick-held lift nets. The dominant species taken by the drive-in net method were *C. coeruleus*, *C. pisang*, and *C. chrysozonus*.

The best baitfish in Truk is the takabe, *Gymnocaesio argenteus* (Wilson 1971). It is hardy and can be confined under crowded conditions with good survival. It is captured on the reefs during the day by divers using a drive-in net. It appears in the lagoon around May or June when quite small and is not abundant from January through April. The larger adults called akamoro are evidently not good for tuna. Jones and Kumaran (1964) noted the use of *G. argenteus* at Minicoy Island, Laccadive Archipelago.

Two species considered by Kearney et al. (1972) to have good baitfish potential in Papua New Guinea are *Gymnocaesio gymnopterus* and *Pterocaesio pisang*. They are apparently good bait species in all respects and relatively abundant and hardy. Lewis et al. (1974) noted that preliminary estimates of abundance by Kearney et al. (1972) may have been premature since they were based only on two collections. The former is the most important bait species captured by the drive-in net method in the Bismarck Sea (Kearney 1973).

Hida (1971) observed these fishes during a baitfish survey in Micronesia over coral outcroppings close to the lagoon drop-off. Some schools were equivalent to about 10 buckets (36.4 kg).

Two species of the genus *Lutjanus* have been used to capture skipjack tuna. Cleaver and Shimada (1950) noted *L. vaigiensis* was used in the Japanese and Ryukyu Islands but they make no comment on its capture or quantities used. It has been reportedly captured by seining along with other baitfishes in shallow water at Canton Island (Anonymous 1950b). Jones (1964b) reported *L. kasmira* is occasionally used in the Laccadive fishery in the Indian Ocean.

Snappers, especially bananafishes, appear to hold good potential as live baitfishes for skipjack tuna since they are hardy and quite effective as bait. Their main drawbacks according to the available literature are that they are seasonal in abundance and it is primarily the juveniles that are effective as live bait.

Mugilidae

Mulletts are found throughout the warm oceans of the world; they occur in both fresh and salt water and are important food fishes. The juveniles occur seasonally and are considered to be a favorable live baitfish. They occur in schools in lagoons, along the shore in shallow water, and on reef flats where they are captured with bait seines usually along with other species. The juveniles have a silvery, oblong body without prominent markings and with large scales that are firmly attached.

At least four species of *Mugil* have been used for skipjack tuna (June 1951a; Ikehara 1953; June and Reintjes 1953). The grey mullet, *M. cephalus*, is relatively hardy and can withstand long distance transport, but, because of the greater availability of nehu, it is of little importance as a baitfish in Hawaii (Ikehara 1953). June and Reintjes (1953) reported that it is a fair baitfish, abundant at Midway Island. They also note that *M. longimanus* and *M. vaigiensis* are fair baitfishes occurring in considerable quantities in the Phoenix and Line Islands. At Palmyra Island, *M. trichilus* was observed in schools with *Crenimugil crenilabis* and *M. vaigiensis* up to a hundred scoops in quantity (June 1951a). Whether sufficient supplies are there to support a fishery is not known. Both *M. vaigiensis* and *C. crenilabis*, 2.5 to 30.4 cm in length, were most common at Canton Island. Ikehara (1953) noted that *M. vaigiensis* and *M. longimanus* are the most common mullets in the Line and Phoenix Islands and could be used whenever available. A baitfish survey there by the NMFS research vessel *Hugh M. Smith* resulted in the capture of 1,135 buckets of live bait including several species of mullets.

Tests at sea were conducted by Yuen (see footnote 4; 1969) with *M. longimanus*. He found with this species the catch rate was better without the water spray in use. Skipjack tuna responded equally to juvenile tilapia and *M. longimanus* when the two were used alternately on the same school.

Crenimugil crenilabis is a fair baitfish, but it is not as common in the Line and Phoenix Islands as other species of mullets (June and Reintjes 1953). It is a primary species at Palmyra Island along with *M. vaigiensis* and *M. trichilus*, with schools varying in size from a few to a hundred or more scoops (June 1951a).

The false mullet, *Neomyxus chaptalii*, was reported by June and Reintjes (1953) to be a fair live baitfish. In Hawaii, it is most abundant in the northwest Hawaiian Islands and is usually caught while seining for other species. Ikehara (1953) noted that this species and *M. cephalus* were the most common mullets in Hawaii and that they were not used as live bait due to their value as food.

Jones (1964a) reported the use of small *C. crenilabis* in fairly large numbers in the Laccadive fishery, Indian Ocean. Another useful mullet in this fishery, but not as abundant in the baitfish catches, is *Valamugil seheli*.

Several mullets (species unknown) were used to capture yellowfin and skipjack tunas during exploratory fishing in the Line Islands (Anonymous 1951; Yuen and King 1953) but bait was scarce. Two species of mullets were the only baitfishes available in accessible areas of the lagoon and outer beach at Palmyra; however, quantities of mullet and goatfish were observed at Christmas Island and along the beaches at Palmyra (Smith and Schaefer 1949). Difficulties were encountered in transporting bait in the bait receiver because of the shallow inshore water. *Mugil* spp. were also captured at Midway and Canton Islands and reportedly survived well (Anonymous 1950a, b), but they were scarce at Hull Island. During exploratory fishing for tuna in the Line Islands,

Ikehara (1953) observed that small mullet reacted favorably when chummed except when weak or injured individuals were used.

According to the above reports young mullet represent a limited baitfish resource for tuna in the tropical Pacific. They are moderately effective and considered to be relatively hardy with reasonable care. Their main disadvantages are that the juveniles occur seasonally and they are a food fish of considerable importance.

Mullidae

Several species of goatfishes have been used to capture skipjack tuna in the tropical Pacific, but they usually occur in limited quantities. They are found close to shore in lagoons, bays, and on the reef flats or along sandy beaches. Occasionally they form small to moderately large aggregations and are usually captured in bait seines during the day, frequently with other species. Most adults are brightly colored with an elongate compressed body, large scales, and with two unbranched barbels on the lower jaw. They are generally found all year. In Saipan they are most abundant from June through August (Ikebe and Matsumoto 1938) and are captured both day and night in beach seines. They are evidently used only when more desirable baitfishes are unavailable.

June (1951a) reported goatfishes are abundant at Palmyra and Canton Islands in June, July, and August but only enough for limited fishing. They were also observed at Christmas Island by Smith and Schaefer (1949) and by Yuen and King (1953); the latter reported they were 20 to 25 cm in length and too large for skipjack tuna.

Small *Mulloidichthys*, called oama in Hawaii, are used whenever available and at times occur in fair quantities in the northwest Hawaiian Islands and in the Line and Phoenix Islands (Ikehara 1953). The two species listed by June and Reintjes (1953) were *M. samoensis* and *M. auriflamma*. Reports on their behavior when used as chum were conflicting—some observers noted that they school at the surface around the vessel and others reported that they sound (Ikehara 1953). Their usefulness as a live baitfish is limited although they are relatively hardy.

Young *M. samoensis* are not used to any great extent but occur in the baitfish catches occasionally and are considered to be suitable (June and Reintjes 1953). Hida (1971) reported that juvenile goatfishes, mostly *M. samoensis*, were common in Micronesia but not in suitable concentrations.

Tests at sea were conducted by Yuen (see footnote 4; 1969) with *M. samoensis* and with *Mulloidichthys* sp. to determine their value as live baitfishes. It was observed that when young goatfishes were used the catch rate was higher when the vessel's water spray was in operation and seemed to be independent of the rate of attack, but since the tests were brief the results are questionable. They were also noted to dive when chummed.

June and Reintjes (1953) listed *M. auriflamma* as a suitable baitfish in Hawaii while its use in the Lac-

cative fishery, Indian Ocean, was reported by Jones (1964a).

Information on the remaining species of goatfishes used for skipjack tuna is fragmentary. Cleaver and Shimada (1950) listed four genera that were used in Japan and the Ryukyu Islands and in the "south seas": *Mullus*, *Pseudupeneus*, *Upeneus*, and *Upenoides*. The latter genus should more correctly be *Upeneoides*, a synonym of *Upeneus*, while *Pseudupeneus* refers to *Parupeneus* (see Lachner 1960).

Marukawa (1939) reported juvenile *Upeneus tragula* were captured in drive-in nets during the day and used when preferred species were scarce. A single record of *Parupeneus pleurostigma* being used as live bait was noted in Anonymous (1950b).

Although no additional goatfishes have been reported for the Indo-Pacific area, Jones (1964a) listed three *Parupeneus* that were occasionally used in the Laccadive fishery, Indian Ocean: *P. macronema*, *P. bifasciatus*, and *P. barberinus*. Juveniles of *P. macronema* were noted to be an esteemed baitfish but they do not occur in large numbers.

Young goatfishes are suitable as baitfishes and used when more desirable species are not available. According to the preceding reports they are comparatively unimportant to the fishery, but they are occasionally captured with other bait species. In Hawaii, their primary value is as a food fish.

Pempheridae

Two species of this family have been used as live bait for skipjack tuna. They are small, compressed, deep-bodied fishes with large eyes and relatively large scales. They are occasionally found in shoals. *Parapriacanthus beryciformis* is of some importance in the Ryukyu Islands fishery (Isa 1972) but no information was given on its use or capture. Its color was described as translucent pinkish. Raju (1964) reported that *Pempheris vanicolensis* was used as a live baitfish to capture skipjack tuna during a study in the Indian Ocean. Considering the nature of the bait fishery in the Laccadive Archipelago, all reef fishes are used as live bait without any apparent selection other than size. Species such as the above were frequently in the baitfish catches but probably not in significant quantities.

Plecoglossidae

The ayu, *Plecoglossus altivelis*, found in Japan, is an anadromous fish that has been viewed with interest as a possible baitfish. Specimens of *P. altivelis* were imported to Hawaii from Japan for experimental purposes as live bait for skipjack tuna.¹² No information on experiments with this species appears available. The baitfish poten-

¹²Report, Aku Committee Meeting, November 7, 1968. Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.

tial of *P. altivelis* is diminished by its being anadromous and an important food fish.

Poeciliidae

Topminnows, called mosquitofishes or tabai in Hawaii, have been used as a supplementary live baitfish since the early 1930's during periods when nehu were scarce. Although reported to be less effective than nehu, various species were in demand and extensively used as bait for skipjack tuna (Bell and Higgins 1939). They were first introduced to Hawaii from the U.S. mainland in 1905 for mosquito control and have since spread throughout the islands. They are small, viviparous fishes, variable in color, and capable of reproducing in a variety of freshwater and seawater environments (Baldwin 1974). An undetermined species originally from tropical Mexico was introduced to Saipan and Palau as a possible live baitfish but evidently it was not tested on skipjack tuna (Ikebe 1939).

A brief test was conducted at sea in 1972 with two buckets of topminnows, *Poecilia vittata*, cultured at the Hawaii Institute of Marine Biology. The test to determine their effectiveness on skipjack tuna was inconclusive because of the limited supply. No skipjack tuna were captured but tuna were observed to feed on the topminnows, about 60% of which slowly spiralled downward while the remainder swam near or just below the surface with some forming aggregations near the vessel (Baldwin 1974).¹³ During this test, one of the researchers¹⁴ observed from an underwater observation port that many exhibited a whirling behavior upon hitting the water. Some continued to a depth of 6 to 8 ft before returning to normal swimming. These, and the remaining individuals, dispersed in all directions, some forming small or tightly packed aggregations with many swimming towards the vessel. The silvery-white belly was visible at a considerable distance in the clear water, especially among those individuals exhibiting the whirling behavior. King et al. (see footnote 7), after testing threadfin shad with mosquitofish (species unknown), observed that the latter were completely ignored by the feeding skipjack tuna that were avidly taking shad.

Tests were conducted with 11 buckets of Mexican mollies, *Poecilia mexicana*, from February to April 1974 in American Samoa aboard the research vessel *Alofaga* (S. N. Swerdloff, Office of Marine Resources, Pago Pago, American Samoa, pers. commun.). These preliminary tests indicated that cultured topminnows are suitable as baitfish for skipjack tuna and that shipboard mortalities are insignificant. These tests also demonstrated that for maximum effectiveness traditional pole-and-line techniques will require some modifications. These include methods of school approach, vessel speed during chum-

ming, quantity of baitfish used, manner of chumming, and lure design and lure use during fishing. Cultured *P. mexicana* gave an equivalent catch rate when compared with mixed natural bait that consisted of *Sardinella*, *Caranx*, and *Selar*. Culture of *P. mexicana* is described briefly by Swerdloff (1973) and that of *P. vittata* by Baldwin (1972,¹⁵ 1973c, 1974) and Herrick and Baldwin (1975).

June and Reintjes (1953) reported that *P. latipinna*, the sailfin molly, was the most important of the topminnows used in Hawaii, and that *P. sphenops* and *P. vittata* were occasionally captured along with the former species. They noted that *P. latipinna* was especially important at times when other bait species were scarce. Brock and Takata (1955) noted *P. latipinna* and *P. vittata* were seldom used for bait in Hawaii and together accounted for only 0.05% of the baitfish catch from 1948 to 1953. Welsh (1950) reported that two mosquitofishes, *P. latipinna* and *P. sphenops*, were used when nehu and iao were scarce. He noted that they occurred extensively in brackish water throughout Hawaii, especially in shallow marshy areas in fish ponds. When chumming, a special method of pinching the head of individual fish was used to alter their behavior in order to attract the skipjack tuna schools to the vessel.

The response of skipjack tuna to nehu and to the topminnow, *P. vittata*, when chummed alternately on the same school was compared by Yuen (see footnote 4). The nehu and topminnow combination, when chummed on skipjack tuna, was observed to receive the same response as tilapia, *Tilapia mossambica*, and mullet, *Mugil longimanus*, and tilapia and mountain bass, *Kuhlia sanduicensis*, combinations. Ikehara (1953) reported that topminnows (genus *Poecilia*) were used in Hawaii during periods when nehu and iao were in short supply. They were noted to occur in streams and estuaries of the main Hawaiian Islands. They were not an ideal tuna bait, however, because they sounded when thrown as chum. Bell and Higgins (1939) noted that *Gambusia* sp. was employed as a live baitfish and that there was a possibility of raising them in Hawaii.

Polynemidae

Threadfins are widely distributed in the tropics and juveniles of several species are occasionally used as chum for skipjack tuna. They are greyish above with silvery sides and with an oblong, compressed body. Many are found close to shore, along beaches, in bays and harbors, and in shallow water over sandy bottom. Their value as a baitfish is limited since it is difficult to capture enough for pole-and-line fishing. They are usually taken incidentally while seining or night lighting for other species.

Juveniles of *Polydactylus sexfilis*, called moi-iii in

¹³This species was previously reported by Baldwin (see footnote 15, 1973c, 1974) as *Poecilia sphenops*.

¹⁴Dollar, S. 1972. Field observations of molly behavior aboard the RV CHARLES H. GILBERT, September 1972. Unpubl. rep., 2 p. Hawaii Institute of Marine Biology, Univ. Hawaii, Honolulu, HI 96822.

¹⁵Baldwin, W. J. 1972. A preliminary study on the feasibility of pond rearing sharpnose mollies (*Poecilia sphenops*) as a live baitfish for the skipjack tuna fishery, American Samoa. Hawaii Inst. Mar. Biol., Univ. Hawaii, Contract Rep. C-248-73, 11 p.

Hawaii, are captured while seining for nehu but small numbers are occasionally taken while night lighting. The young do not closely resemble the adults in color, and those smaller than 10.0 cm in length have several pronounced dark bars on their bodies. Jones (1964a) briefly noted that small *P. sexfiliis* are suitable as live bait in the Laccadive fishery, Indian Ocean, but are not abundant.

Polydactylus sp. was listed by Alverson and Shimada (1957) and IATTC (1952) as a baitfish occasionally used in the eastern Pacific fishery. It is captured from Baja California, Mexico, to the Gulf of Guayaquil, Ecuador. Both eastern Pacific species, *P. approximans* and *P. opercularis*, were no doubt included in the bait catches.

Pomacentridae

The damselfishes appear unlikely as live baitfishes for skipjack tuna, but reports covering a wide geographic range substantially document their use. They are a secondary baitfish and are used when more desirable species are scarce. Since they are closely associated with coral reefs, special techniques such as the drive-in net method have been developed for their capture. Most are small and brightly colored, with a flattened, deep to oblong body, and they are usually seen darting in and around coral heads with some species occurring in aggregations.

Wilson (1971) reported that *Pomacentrus pavo* was used by the Japanese at Truk and Saipan when other baitfishes were not available. It was difficult to capture and one method employed, that of breaking off coral heads to catch them, was obviously very destructive. It would take 20 men 1 day to catch a bucket of bait, and three or four buckets were required for fishing. This species was described as an adequate bait but was used sparingly due to the effort required to capture it. In Saipan, *Abudefduf coelestinus* (listed as *A. sexfasciatus*) was used, but only as a last resort (Ikebe and Matsumoto 1938). Small individuals, 1.7 to 2.0 cm in length, are found inside the reef and are evidently present all year. Large individuals are not suitable live bait.

The most important damselfish in the Ryukyu Islands fishery is *Chromis ternatensis* (Isa 1972). That author also listed *C. caeruleus* and *Abudefduf dicki* and stated that these three species combined made up 4.1 to 6.1 t of live bait in 1966 and 1967, respectively. Damselfishes played a minor role as tuna bait in the Ryukyu Islands fishery in 1966 and 1967, as these figures indicate.

Jones (1964a) reported *C. ternatensis* and *C. caeruleus* were used to some extent in the Laccadive fishery, Indian Ocean. While he noted that *C. ternatensis* occurs commonly in baitfish catches, *C. caeruleus* is second in importance among the pomacentrids, the first being *Lepidozygus tapeinosoma*. Jones and Silas (1963) regarded *L. tapeinosoma* as the most suitable of all the baitfishes at Minicoy Island. *Chromis caeruleus* is used mainly at the beginning of the tuna season and may occur in fairly large numbers (Jones 1964a). Thomas (1964) noted that *C. caeruleus* formed 2.1% of the total baitfish catch during 1960 and 1961 in the Minicoy Island fishery.

Dascyllus trimaculatus was used in the "south seas" by the Japanese and *Abudefduf anabatoides* in Japan and the Ryukyu Islands fishery (Cleaver and Shimada 1950). No further comments were made regarding either species. A report by the Far Seas Fisheries Research Laboratory (1969) listed the three families Pomacentridae, Abudefdufidae, and Chromidae as being worthy of consideration as a possible live bait resource in the Bismarck Sea area. [I follow Norman (1966) in placing these all in the Pomacentridae.] Kearney et al. (1972) noted the family Pomacentridae has potential as a baitfish resource in Papua New Guinea and that it is rarely encountered in a night bait fishery. Little additional information on the use of damselfishes in the Indo-Pacific fisheries appears available. They no doubt occur in baitfish catches throughout the area but most frequently in small numbers.

Damselfishes hold some importance in the Laccadive fishery (Jones 1958, 1964a; Jones and Kumaran 1959; Raju 1964; Thomas 1964). These authors listed *Abudefduf anabatoides*, *A. biocellatus*, *Chromis caeruleus*, *C. dimidiatus*, *C. ternatensis*, *Dascyllus aruanus*, *Lepidozygus tapeinosoma*, *Pomacentrus* sp., and *P. tripunctatus* as live bait. They are not of major importance except for *L. tapeinosoma* and *C. caeruleus*. Jones (1964a) noted that the former is the most important tuna bait used at Minicoy Island and that it occurs in large schools although it is occasionally scarce. It is suitable due to its high rate of survival and it is active and very effective on tuna (Thomas 1964). Its peak abundance in January coincides with the peak tuna catch. In the Minicoy Island fishery, *L. tapeinosoma* has the best survival rate and when chummed it swims towards the vessel and takes shelter in the shadow of the boat.

Priacanthidae

Juveniles of *Priacanthus* sp., called bigeyes or aweoweo in Hawaii, are briefly noted by Cleaver and Shimada (1950) as having been used as skipjack tuna bait at Ponape and Truk. It is doubtful that they were taken in quantity especially when other more accessible bait species were available.

Pristipomatidae

Several species of this family, commonly called salemas, have been used in the eastern Pacific as live bait for tuna. They are usually 25 cm or less in length and are known to be hardy. They generally have several longitudinal dark stripes on the body, large eyes, and small scales. The California salema, *Xenistius californiensis*, is noted by Roedel (1953) and Alverson and Shimada (1957), as occasionally taken in Baja California, Mexico, but it was evidently not important to the fishery.

Anderson et al. (1953) noted that two species of salemas have been used in the Galapagos Islands and they were noted to be hardy. Alverson and Shimada (1957) reported that *Xenocys jessiae*, restricted to the

Galapagos Islands, was the only nonclupeoid fish of importance as tuna bait in the eastern Pacific fishery. The second salema noted by Anderson et al. (1953) was probably *Xenichthys agassizi*, also restricted to the Galapagos Islands. It is favored as hook bait since it is quite hardy but the sharp dorsal spines are a nuisance. Capture is usually by seine in shallow water during the day near rocky shores and in sheltered rocky coves.

Scombridae

Reports of the use of juvenile scombrids to capture skipjack tuna are primarily from the western tropical and subtropical Pacific; however, Alverson and Shimada (1957) noted that *Scomber* sp. was used in the eastern Pacific fishery as a miscellaneous baitfish.

Cleaver and Shimada (1950) noted without further comment that *Scomber japonicus* was used in the Japanese and the Ryukyu Islands fisheries. Sampson (1962) reported that this species was also used successfully in Australia as bait for tuna. In reference to baitfishes in general, he noted that 15 cm is the most useful size and that probably any small local fish would be suitable. Imamura (1949) reported small mackerel and small skipjack tuna were used in the Miyasaki area of Japan, but whether or not the latter is in fact *Katsuwonus pelamis* is not known.

The most common scombrid used as bait for skipjack tuna is *Rastrelliger kanagurta*, commonly known as striped mackerel or saba in Japan. Marukawa (1939) noted that juvenile *R. kanagurta*, 12 to 13 cm in length, were used as live bait in the "south seas." They were usually captured along with other bait species in lift nets, but were not abundant. A report by the Far Seas Fisheries Research Laboratory (1969) noted that the juveniles were observed in the Bismarck Sea several times in great numbers and that they were attracted to lights.

According to Lee (1973), *R. kanagurta* is used in Fiji but it is a baitfish taken in lesser quantities. Cleaver and Shimada (1950) noted that it was used by the Japanese in the "south seas" fishery, and Hida (1970b, 1973) reported its capture in Pago Pago Harbor, American Samoa. Details on its effectiveness were not given because of the limited amount used. They died several hours after capture probably from overcrowding that resulted in oxygen deficiency.

Domantay (1940a, 1940b) briefly noted the use of juvenile *R. kanagurta* in the Philippines, with a description of baiting and fishing methods.

Sphyraenidae

An unlikely species used as a live baitfish for skipjack tuna is the barracuda, *Sphyraena obtusata*. The juveniles were captured with night lights and a lift net but they were not captured in great numbers (Marukawa 1939). They were not especially suited for skipjack tuna but were used when other species were scarce. Cleaver and Shimada (1950) noted its use by the Japanese in the

"south seas" and Domantay (1940a, 1940b) reported its use in the Philippine fishery.

A report by the Far Seas Fisheries Research Laboratory (1969:170) noted that juveniles were sometimes used for tuna but were not in abundance.

Tetragonuridae

The successful use of the squaretail, *Tetragonurus atlanticus*, by the Japanese to capture skipjack tuna was recently reported by Otsu (1975). Large quantities of this species were captured on the "high seas" near the eastern Caroline Islands by night lighting. They were 4 to 7 cm long and reported to be a satisfactory baitfish that swims slowly at the surface when chummed. They are dark in color, slender, elongate, and reported to be easily maintained in baitwells for 16 days.

REMARKS

It is apparent that further studies on live baitfishes are warranted, especially research related to improved capture and handling methods, natural stocks, baitfish behavior, and tuna attractability, baitfish culture, and the use of live baitfishes in combination with other fishing methods. The wide variety of fishes successfully employed as bait for skipjack tuna in the Pacific indicates that a critical examination of traditional pole-and-line fishing techniques would be worthwhile. One specific method may be highly effective using a particular species of baitfish but less effective using another species. It is reasonable to believe that certain modifications to the standard handling methods, ship-board live-bait holding facilities, vessel approach to schools, chumming techniques, lure use, and lure designs may significantly improve the use of many bait species for capturing skipjack tuna.

The single most important key to expanding existing skipjack tuna fisheries and developing new fisheries in Pacific island areas now known to be "bait poor" lies in the availability of suitable baitfishes throughout the year. The information included in this report on baitfishes and their use provides a basis for recognizing the various factors that seem to be important qualities in a good bait species. Without question, the anchovies (*Engraulidae*) provide the greatest source of desirable baitfishes in the eastern and western Pacific and to some extent in the central Pacific. They have a behavior that is highly attractive to skipjack tuna, are generally less than 15 cm in length, silvery, and elongate, and they form aggregations nearshore where they can be obtained by day and night capture methods. However, their survival in baitwells, depending upon the species involved, may be from excellent to poor. In areas where there appears to be an abundance of baitfishes (Papua New Guinea, Japan, eastern Pacific) the main factors restricting growth of the fisheries through geographical expansion are technological rather than restricted natural bait resources. Here the major baitfish requirements are behavior (attractability to tuna) and survival. The longer the dis-

tance baitfishes must be carried aboard ship, the greater the emphasis upon survival. In areas where baitfishes are unavailable on a commercial fishery level, then the order of relative importance is obviously availability, survival, and behavior, with such characteristics as size, body coloration, and body shape being of less importance. For example, in American Samoa baitfish catches usually produced limited quantities of mixed species including anchovies, herrings, carangids, mullets, etc., all relatively good baitfishes that are useful on a small fishery level but offer little potential for commercial pole-and-line fishery growth. Live baitfishes must either be reared locally or imported from areas of abundance. Fishery development may also occur through improved purse seining technology, the application of electronics, chemical attractants, manufactured bait substitutes, etc., but fishery development in Pacific island areas through these means appears unrealistic at least for the present. Until alternate means are available through research and development that can be applied to the skipjack tuna fishery, live baitfishes must be made available economically in quantity throughout the year from high density culture techniques or by shipment of baitfishes from areas of abundance.

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